

Status Review Report: **Thorny Skate (*Amblyraja radiata*)**



2017

National Marine Fisheries Service
National Oceanic and Atmospheric Administration

ACKNOWLEDGEMENTS

The National Marine Fisheries Service (NMFS) gratefully acknowledges the commitment and efforts of the Extinction Risk Analysis (ERA) workshop participants and thanks them for generously contributing their time and expertise during our development of this status review report.

EXECUTIVE SUMMARY

This status review report was conducted in response to a petition to list either the United States or North Atlantic populations of thorny skate (*Amblyraja radiata*) as Distinct Population Segments (DPSs) under the Endangered Species Act (ESA) (petitioners: Animal Welfare Institute and Defenders of Wildlife, May 28, 2015). We evaluated the petitions to determine whether the petitioners provided substantial information as required by the ESA to list a species. Additionally, we evaluated whether information contained in the petitions might support the identification of a DPS that may warrant listing as a species under the ESA. We determined that the petitions presented substantial scientific and commercial information, or cited such information in other sources, that the petitioned action may be warranted and, subsequently, initiated a status review of thorny skate. This status review report is comprised of two components: (1) the “Status Review” of the species, a document that compiles the best available information on the status of thorny skate as required by the ESA, and (2) the “Assessment of Extinction Risk” for the species, a document that provides the methods and conclusions of the NMFS Extinction Risk Analysis (ERA) on the current and future extinction risk of thorny skate.

Thorny skate is widely distributed within deeper waters of the North Atlantic. Its range spans from western Greenland (Davis Strait) and Hudson Bay, Canada to South Carolina in the Western North Atlantic and from Svalbard, Greenland, Iceland to the southwestern coasts of Ireland and England, also to the North Sea and western Baltic in the Eastern North Atlantic. Thorny skate have low productivity, though a higher rate of productivity compared to other elasmobranchs and sympatric species, with a generation time of approximately 16 years and a low rate of reproduction. These life history traits make the populations vulnerable to overfishing and slow to recover from depletion.

Available survey information indicates that Northwest Atlantic thorny skate in U.S. waters have decreased by as much as 80-95 percent in some areas since the 1970s. Meanwhile, area occupancy has also declined. Thorny skate abundance indices in the Northeast Atlantic have remained stable over the same time period.

Based on a review of the best available information, the workshop participants individually determined that there are no distinct population segments (DPSs) of thorny skate, as defined by the joint U.S. Fish and Wildlife Service-NMFS interagency policy of 1996 on vertebrate distinct population segments under the ESA, and we agree. As such, workshop participants individually evaluated the extinction risk of thorny skate as a species. Individual workshop participants ranked the demographic parameters of abundance, growth rate/productivity, spatial structure/connectivity, and diversity in terms of their risk to the species’ continued existence.

Low abundance and life history traits (e.g., growth rate, late maturity, productivity rates, and low fecundity) were ranked as moderate risks to the species’ continued existence, meaning these

demographic parameters pose a significant risk to the species' continued existence. Spatial structure/connectivity and diversity, however, were not found to pose significant risks to the thorny skate's continued existence.

Thorny skates have low inherent productivity due to their late age at maturity, low fecundity, slow population growth rates, and long generation times (16 years). This low productivity makes thorny skate populations vulnerable to overexploitation, and slow to recover from depletion. The mean score we calculated based on the workshop participants' scores indicated that a *Low to Moderate* ranking was warranted rangewide for growth/productivity meaning this factor is unlikely to contribute significantly to the thorny skate's risk of extinction. Abundance, spatial structure/connectivity and diversity, however, were not found to pose significant risk, meaning these factors are very unlikely to contribute significantly to the thorny skate's risk of extinction.

The workshop participants also individually ranked the ESA section 4(a) threats to thorny skate. The mean score we calculated based on the workshop participants' scores indicate that climate change, manmade non-fishing habitat impacts, commercial discards, commercial landings, global and national climate regulation, and inadequacy of existing NAFO regulations rank in the low to moderate category for contribution to extinction risk including . Climate change and global or national climate change regulations received the most likelihood points in the moderate contribution to extinction risk category. Only one threat, climate change received likelihood points in the high contribution category. No threats considered by the individual workshop participants were given an overall average score to classify as high or very high contributions to extinction risk of thorny skate. Individual workshop participants all gave point allocation for very low contribution to extinction risk from threats such as recreational fishing, recreational discards, educational collection, and stochastic events. Based on an evaluation of abundance trends, growth and productivity, spatial structure, and diversity, as well as the ESA section 4(a)(1) threats listed above, workshop participants provided their individual expert opinions on the current level of extinction risk as well as extinction risk in the foreseeable future (which was defined as 40 years) for thorny skate. The individual workshop participants provided expert opinions that thorny skate as a species have a low risk of extinction currently, or in the foreseeable future. Finally, the workshop participants individually answered questions related to significance outlined in the NMFS Significant Portion of Its Range (SPR) policy. After a review of the best available information, the workshop participants' expert opinions do not indicate any portion of the thorny skate's range (Northwest Atlantic, Northeast Atlantic, US) meet the significance prong for the SPR policy.. These analyses and conclusions will be considered during NMFS' decision-making process on whether or not ESA listing is warranted for the thorny skate.

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STATUS REVIEW OF THE THORNY SKATE (*Amblyraja radiata*)



Photo: D. Flescher, NOAA Fisheries

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INTRODUCTION

Scope and Intent of the Present Document

This status review report was developed in response to a petition to list either the United States or North Atlantic populations of thorny skate (*Amblyraja radiata*) as Distinct Population Segments (DPSs) under the Endangered Species Act (ESA) (petitioners: Animal Welfare Institute and Defenders of Wildlife, May 28, 2015). Under the ESA, if a petition is found to present substantial scientific or commercial information that the petitioned action may be warranted, a status review shall be promptly commenced (16 U.S.C. 1533(b)(3)(A)). In response, we published a positive 90-finding in October 2015 concluding that listing this species under the ESA may be warranted. The finding concluded that petition contained evidence that: 1) thorny skate populations in southern Canada and the United States have declined; 2) fishing and climate change may be contributing to this decline ;and, 3) due to differing management regimes and population dynamics, listing of a thorny skate DPS may be warranted.

This report comprehensively reviews the best available scientific information on the status of thorny skate, evaluates the factors contributing to the species' proposed threatened or endangered status according to the petitions and other available information and includes an assessment of the species' risk of extinction, providing the information necessary for us to make a determination on the potential listing of this species (or its distinct population segments) under the ESA.

Key Questions in ESA Evaluations

In determining whether a listing under the ESA is warranted, two key questions must be addressed:

- 1) Is the entity in question a "species" as defined by the ESA?
- 2) If so, is the "species" threatened or endangered?

The ESA (section 3) defines the term "endangered species" as "any species which is in danger of extinction throughout all or a significant portion of its range." The term "threatened species" is defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." We consider a variety of information in evaluating the level of risk faced by a species in deciding whether the species is threatened or endangered. Important considerations include 1) absolute numbers of fish and their spatial and temporal distribution; 2) current abundance in relation to historical abundance and carrying capacity of the habitat; 3) any trends in abundance; 4) natural and human influenced factors that cause variability in survival and abundance; 5) possible threats to genetic integrity; and 6) recent events (e.g., a drought or a change in management) that have predictable short-term consequences for abundance of the species. Additional risk factors, such as disease prevalence or changes in life history traits, may also be considered in evaluating risk to populations.

NMFS is required by law (ESA Sec. 4(a)(1)) to determine whether one or more of the following

factors is/are responsible for the species' threatened or endangered status:

- (A) The present or threatened destruction, modification or curtailment of its habitat or range;
- (B) overutilization for commercial, recreational, scientific, or educational purposes;
- (C) disease or predation;
- (D) inadequacy of existing regulatory mechanisms; or
- (E) other natural or human factors affecting its continued existence.

According to the ESA, the determination of whether a species is threatened or endangered should be made on the basis of the best scientific and commercial information available regarding its current status, after taking into consideration conservation measures that are being made.

Summary of the Thorny Skate Listing Petitions

The petition submitted by the Animal Welfare Institute and Defenders of Wildlife argue that a Northwest Atlantic or U.S. DPS of thorny skate should be listed as endangered or threatened under the ESA. Their assertions were primarily based on evidence of population declines resulting from overfishing, the species' inherent biological vulnerability to overexploitation, habitat destruction or modification via climate change, and the alleged inadequacy of existing regulatory mechanisms. As described above, this document will evaluate all of these factors and how they affect the risk of extinction for thorny skate throughout all or significant portions of its range.

LIFE HISTORY AND ECOLOGY

Taxonomy and Distinctive Characteristics

The thorny skate (*Amblyraja radiata*, Donovan 1808), is a valid species. The species description history and synonyms are provided by Eschmeyer, (2016). The taxonomic breakdown of *A. radiata* is as follows:

Kingdom: Animalia
Phylum: Chordata
Class: Chondrichthyes
Subclass: Elasmobranchii
Order: Rajiformes
Family: Rajidae
Genus: *Amblyraja*
Species: *radiata*

Range and Habitat Use including Diet and Foraging Behavior

The thorny skate is a widely distributed boreal species, spanning both sides of the Atlantic. In the western North Atlantic, it ranges from western Greenland to South Carolina. In the eastern

North Atlantic, it ranges from the Barents Sea southward to the southwestern coasts of Ireland and England, including Iceland (Bigelow and Schroeder, 1953). Found over a wide variety of substrates including sand, broken shell, gravel, pebbles and soft mud, thorny skates range over depths from 20 to 3,900 feet (18 to 1400m) (COSEWIC 2012). There is some evidence for species preference for complex hard bottom habitat over sand or mud. Scott (1982) reported that catch rates of thorny skate were highest on coarser grained sediment and diminished grain size on the Scotian Shelf. Also, more skates caught by longlines in bottom areas that are considered categorized as rough vs. those considered smooth (Sosebee *et al.*, in prep).

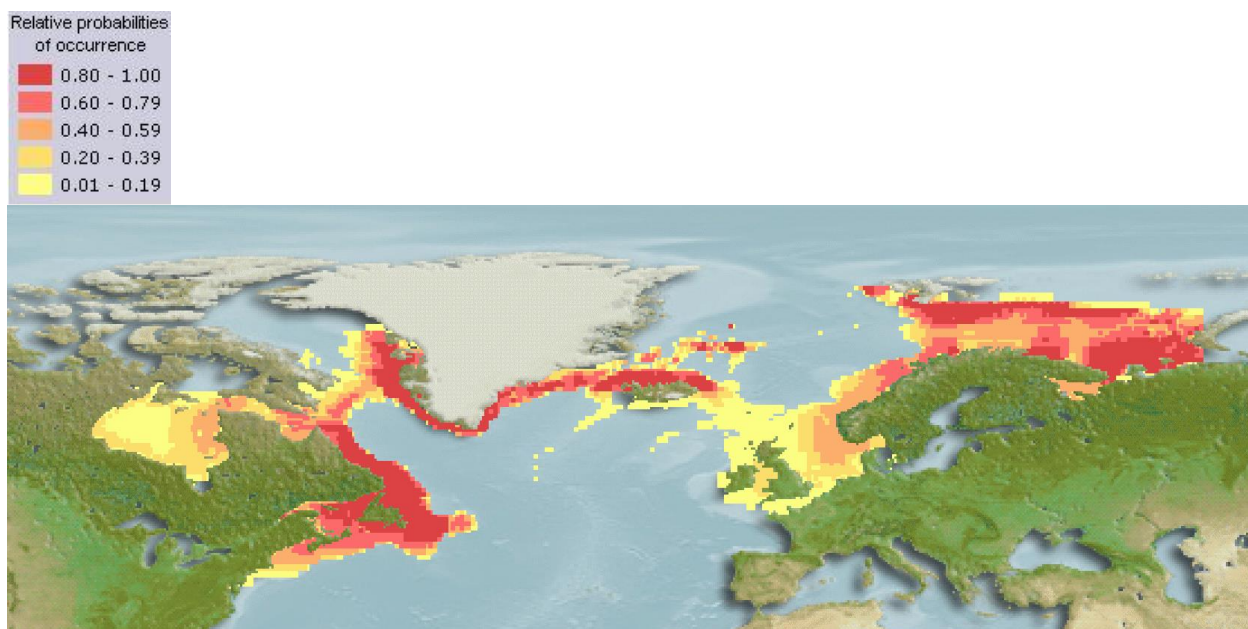


Figure 1. Map of thorny skate range and probability of occurrence from <http://www.fishbase.org>.

Despite its generalist nature, some habitat preferences exist. Generally thorny skate appear to prefer deeper waters within their range, although the specific depth varies by location and may be impacted by other factors including temperature. Survey data from the inshore waters in the Gulf of Maine stratified by depth indicate catch by trawl survey gear increases sharply after 40 m (131 ft) in depth, and peaks at around 95m (312 ft). Most individuals are caught between 70m (230 ft) and the upper depth limit for the survey, 120m (394 ft, Sosebee *et al.*, in prep). Generally within U.S. waters, the range from a depth of 141 to 300 m (463– 984ft) in spring and 31-500m (102-1640ft) in fall, with the majority between 141 and 300m (463 -984 ft) (Packer *et al.* 2003). Previous studies found thorny skate most abundant between 111m and 366m (334-1102 ft) throughout the U.S. range (McEachran and Musick 1975). In Canadian waters from the Labrador Shelf to the Grand Banks, 88 percent of thorny skate are found between 30m and 350m (98-1148 ft, COSEWIC 2012). In the Gulf of St. Lawrence, thorny skate have been found to be increasingly concentrated in depths below 100m since the early 1990s, with the majority of fish greater than 33cm (1.1 ft) in length found around 200m (656 ft, Swain and Benoit 2006). Fish smaller than 33cm concentrate in shallower waters around 100m in the Gulf of St. Lawrence. In Norway, thorny skate show a preference for even deeper waters, being more concentrated

between 600m and 650m (1969-2133 ft, Williams *et al.* 2008). Within the Barents Sea, average catch is highest between 100 and 200m (328-656 ft) in depth but thorny skates are captured all the way to 800m in depth (2624 ft, Dolgov *et al.* 2005a).

Thorny skate have been caught at temperatures ranging from -1.4° to 14° C (29-57°F, McEachran and Muisck 1975), however, they have a more narrow thermal range than most sympatric species (Hogan *et al.* 2013). In the U.S. waters of the inshore Gulf of Maine, surveys catch nearly twice as many skates at 2.5 ° C (36.5°F) than between 4.5 and 9.5° C (40-49°F), with catch rates dropping off sharply for temperatures warmer than 10° C (50°F, Sosebee *et al.* in prep). Generally in U.S. waters during spring, adult thorny skate were found at temperatures between 2-13 C° (35.6-55.4°F), with the majority between 4-7 C°(39.2-44.6°F). During the fall they were found over a temperature range of 3-13C° (37.4-55.4°F), with the majority found between 5-8C° (41-46.4°F, Packer *et al.* 2003). Preliminary, tagging results from a 2016 Gulf of Maine study received data from 23 thorny skate with pop-up satellite archival transmitting (PSAT) tags. The daily (min/max) temperature records from daily temperature records from all PSAT-tagged skates indicated that thorny skate occurred in temperatures of 4.5-10.5°C (40.1-50.9°F) from November to August and have a broad temperature tolerance (J. Kneebone, pers. comm.) On the Grand Banks, catches of thorny skate are generally highest between 3 and 5°C, although catch has concentrated on the warmer edge of the bank since the 1990s (Colbourne and Kulka 2004). A similar concentration on the edge of the banks has been observed in the Gulf of St Lawrence, correlating with temperatures between 2 and 4°C (35-39°F, Swain and Benoit 2006). Few thorny skates are caught where temperature was < 0° C (32° F).

Seasonal migrations have been noted on the Scotian Shelf and the Grand Banks, but are not well understood (NEFSC, 2003). Within the Gulf of St. Lawrence, skates move into deeper waters in November and December and into shallower waters in April and May, with peak numbers present there in late summer and fall (Clay 1991, Darbyson and Benoit 2003). A change in spring and fall distributions results in higher density and concentration of biomass in deeper waters during the spring, corresponding with areas of warmer temperature in Canadian waters (Kulka and Miri 2003). These may be examples of skates seeking out their preferred temperature range.

Little data are available regarding thorny skates preferred salinity, although catch is highest between 32 and 35 practical salinity unit (PSU) (COSEWIC 2012). In U.S. waters during the spring they are primarily caught at salinities of 33-34 PSU and in the fall at salinities of 32-35 ppt, with more than 60 percent at 33 ppt (Packer *et al.* 2003). In the Barents Sea, thorny skate are caught at a much larger range of salinities than other species (Dolgov *et al.* 2004a).

Thorny skate eat a varied diet, with smaller skates consuming copepods, krill, polychaete worms and amphipods and larger skate eating other fish and larger crustaceans including shrimp and crabs (Skjaeraasen and Bergstad 2000, Dolgov 2002). An opportunistic feeder, important fish species can include cod, capelin, and redfish (Pedersen 1995, Dolgov 2002). Within the Gulf of Maine, fish make up the majority of the thorny skate diet, particularly herrings (*Clupeidae* sp., Link and Sosebee 2011).

Overall, thorny skate are considered a habitat generalist, found over a wide variety of substrates,

depths and temperatures. Thorny skate vary widely in depth preferences over the range of the species, likely indicating an ability to seek out ideal temperatures.

Reproduction, Growth, and Demography

Thorny skate, like other skate, ray and shark species, is relatively slow-growing, late to mature and has low fecundity when compared to bony fishes. An oviparous (egg-laying) species they reproduce year-round (Kneebone *et al.* 2007), although more females contain mature egg capsules in the summer (Collette and Klein-MacPhee, 2002). In the Gulf of Maine, average egg capsule size is largest in October (Sulikowski *et al.* 2005a). Mature females are estimated to produce an average 40.5 eggs per year, with a hatching success of 38% (COSEWIC 2012). Others have estimated up to 56 eggs per year, slightly higher than similar species (McPhie and Campana 2009a). Incubation time is long and, depending on temperature (low water temperatures slow development), is estimated to take from 2.5-3 years after deposit (Berestovskii 1994).

Lifespan for the species is difficult to estimate, due to the slow growth of the species and limited number of maximum-sized fish available for aging. This may result from fishing and natural mortality or from differential capture rates for different sized skates. Individuals estimated to be up to 16 years of age using vertebral and caudal thorn aging have been observed from the Gulf of Maine (Sulikowski *et al.* 2005b) and from Greenland (Gallagher *et al.* 2006), respectively. Long-term tagging indicated these fish may live at least 20 years in Canadian waters (Templeman 1984) and further vertebral aging confirmed with radiocarbon bomb dating methodology indicated a maximum age of at least 28 years for individuals caught off the Scotian Shelf (McPhie and Campana 2009). Theoretical longevity was estimated at up to 39 years, much longer compared to other native skates (McPhie and Campana 2009).

Total length and length at reproductive maturity vary widely over the species range. Maximum length and length at maturity (L50) decrease with increases in latitude. Maximum lengths range from 90 cm on the Labrador Shelf to 100-110cm (39.3-43.3 in) in the Gulf of Maine (COSEWIC 2012). The smallest L50s were reported furthest north, with female L50 reported at 440-470 mm (17.3- 17.6 in) and male L50 at 440-500 mm (17.3-19.7 in) reported for skates caught around Baffin Island on the Labrador Shelf (Templeman 1987). In the Gulf of Maine, L50 for females occurred at approximately 11 years and 875 mm (34.5in); for males L50 was reached at 10.9 years and 856mm (34 in) (Sulikowski *et al.* 2005b). A later study on the eastern Scotian Shelf (midway between these populations) noted that female skates could show signs of maturity anywhere from 390-745mm (15.4-29.3in) and males between 510-780mm (20.1-30.1 in, McPhie and Campana 2009). The reasons behind this are unknown but may stem from environmental or genetic factors.

Age at maturity was estimated to be 10.7 ± 0.7 years for females and 14.7 ± 1.4 years for males. Size and age at maturity for thorny skate were greater and also demonstrated more variability than sympatric skate species. (Sosebee 2005, McPhie and Campana 2009). Size and maturity were not found to correlate with depth (Templeman 1987).

Overall, thorny skate was found to have the highest potential reproductive rate and predicted

population increase when compared to sympatric skate species (McPhie and Campana 2009); this may indicate a greater ability to recover from fishing than similar species. Reproductive rate is still considered low overall compared to teleost species.

Population Structure

Tagging Information

Tagging data from both sides of the Atlantic show thorny skates remaining in or returning to the same area with 85 percent of individuals travelling less than 120 km (64.7nm) from their tagging locations (Templeman 1984, Walker *et al.* 1997). In both studies, 13 percent of individuals traveled longer distances between 180 and 445km (97-240nm). Preliminary study results from a 2016 study in the Gulf of Maine recovered data from five thorny skate tagged with PSATs in the vicinity of Cashes Ledge indicated horizontal displacements of 3-26 km (1.6-14 nm) at 100 days post-tagging (J. Kneebone, pers.comm). Three thorny skate tagged offshore in the Gulf of Maine near the Hague line exhibited horizontal displacements of 3.5-6.5 km (1.9-3.5 nm) over 100 days post-tagging. In the western Gulf of Maine (Massachusetts Bay), data from 13 PSAT-tagged skates revealed horizontal displacements of 2-30 km (1- 16.2 nm) over 100 day (n=12) and 200 day (n=1) tag deployment periods (J. Kneebone, pers. comm.). Collectively, these preliminary data corroborate the information previously published data and further demonstrate that thorny skate exhibit limited movements in the Gulf of Maine. However, some skates were observed to travel rapidly, with several individuals moving up 200km (108nm) within a few months (Templeman 1984).

Conventional tagging data has several limitations when it comes to accurately monitoring movement for this species, including that all returns are produced from commercial fishing gear. First, it is reliant on recaptures and reporting (commercial/recreational fishermen or surveys may report catch of a tagged fish) and the information available is generally only the location where the fish was recaptured in relation to where it was originally tagged. Second, the information from conventional tagging is limited by the small number of thorny skates tagged and recaptured. Return rates in the western Atlantic were 14 percent (Templeman 1984) and 25 percent in the eastern Atlantic (Walker *et al.* 1997). The prosecution of fisheries in relatively shallow waters compared to the depth range of the species limits returns and therefore data. A particularly low rate of five percent return was observed for skates tagged offshore (Templeman 1984), making it difficult to understand offshore movements.

Genetic Information

Comparisons with sympatric species suggest thorny skate has one of the highest levels of haplotype and nucleotide genetic diversity when compared to other western Atlantic skate species, although this can be skewed by some individuals (Coulson *et al.* 2011). High genetic diversity was also present in studies that examined additional genetic markers (Chevolot *et al.* 2007, Lynghammar *et al.* 2014). The presence of high genetic diversity may support but does not guarantee differences between populations. Overall, barcode gap analysis finds the genetic distance within the thorny skate species is low compared to the average distance between species in the skate family (0.93 vs. 3.9 percent, Lynghammar *et al.* 2014).

Distribution of genetic diversity did not mirror geographic distribution in the thorny skate (Lynghammar *et al.* 2014). Highest diversity in one study occurred between two adjacent sites in the eastern Atlantic, and when these were removed there was no significant difference in genetic diversity between remaining sites (Chevolot *et al.* 2007). Thorny skate captured in Iceland had the highest levels of diversity with fourteen different haplotypes present; thorny skate from the eastern and western Atlantic sites had significantly lower levels with three haplotypes each. The distribution of specific genetic haplotypes and the depth range of the species likely indicate gene flow across the range of the species (Chevolot *et al.* 2007), as there is no significant gap in distribution across the species range (COSEWIC 2012).

Comparisons of haplotypes between the Northwest and Northeast Atlantic alone were found to be statistically significant; however, no significance was found when samples from Greenland were included (Lynghammar *et al.* 2014). Additionally, Greenland represented a higher number of genetic haplotypes than either the northwest or northeast Atlantic, confirming previous results and suggesting that genetic mixing is occurring in the central portion of the species range (Lynghammar *et al.* 2014).

Further work comparing individuals of different sizes from two sites in the Gulf of Maine and two sites in Canadian waters found no significant genetic differences (Tsang *et al.* 2008). Comparison of “late maturing” skates collected mostly north of Newfoundland and “early maturing” skates collected within Canadian waters south of Newfoundland also found no significant differences (Lynghammar *et al.* 2014).

In summary, current information indicates skates in the Northwestern Atlantic comprise a single stock, despite the differences in length and length at maturity. Some genetic differentiation is present between the Northwest Atlantic and Northeast Atlantic, but the central portion of the range appears to bridge diversity between these two areas. This is likely made possible by the continuous distribution and depth range of the species.

DISTRIBUTION AND ABUNDANCE

The thorny skate is widely distributed within deeper shelf waters of the Atlantic. Its range spans from western Greenland to South Carolina in the Western North Atlantic and from Iceland to the southwestern coasts of Ireland and England in the Eastern North Atlantic.

Description of Population Abundance and Trends

The best available information regarding population abundance and trends is provided by independent trawl surveys within different regions of the species range. Trawl surveys severely underestimate thorny skate abundance as skates are able to escape capture by sliding under the foot rope of trawl gear (Templeman 1984). Capture efficiency varies widely with the configuration of the gear and size of the fish, as well as area (COSEWIC 2012), making it difficult to compare results or pool surveys. In addition, surveys are generally conducted to support fisheries management and are designed for other (commercial) species and thus may not be optimal for skate. In Europe, these areas do not always overlap with areas of known thorny skate abundance, particularly in deeper waters (Templeman 1984, Walker and Hislop 1998).

Across the species range, available data vary widely in survey gear, timing of surveys, and time series, making comparisons between different areas difficult (COSEWIC 2012).

Additionally, trawl surveys are limited in the types of bottom they can survey. For trawls, catch efficiency increases with the smoothness of the bottom. The roughest bottoms may be avoided to prevent gear hang-ups. The increase in number and length of skates caught by longline surveys, particularly on rough bottom (Sosebee *et al.*, in prep), confirms that trawl gear underestimates total abundance and biomass of thorny skate (Dolgov *et al.* 2005b).

Trawl survey data is thus limited in two ways: by location, missing an unknown portion of the species' preferred habitat, and by catch efficiency, underestimating the number of skates in surveyed areas. Trawl survey data therefore are an index and represent a minimum estimate of overall thorny skate. Trends are still evident from these data but may be somewhat overestimated, given the lack of information collected beyond the survey areas and the unknown proportion of individuals in untrawlable habitat (see Davies and Jonsen 2011).

United States Waters

Northeast Fisheries Science Center Surveys

In U.S. waters, the relative abundance of thorny skate is measured via the Northeast Fisheries Science Center (NEFSC) bottom trawl surveys. The NEFSC trawl survey has been conducted in the autumn from the Gulf of Maine to Southern New England since 1963 as a method of measuring abundance of groundfish for fishery management purposes. A spring survey was started in 1968. We focus on autumn numbers as these provide a longer time series and are used for stock assessment purposes. For most of the time series, thorny skate abundance is higher during the autumn survey.

Numbers and catch-per-unit-effort (CPUE; abundance or biomass per tow) of thorny skate caught by this survey have declined (see Figure 2). After reaching a peak during the 1970s with 5.3 kg/ 11.68 lbs per tow (2.9 fish per tow) during the spring survey and 5.9 kg/13 lbs per tow (1.8 fish per tow) in the autumn survey, catch has declined to less than five percent of these maximum levels, with the average current weight from 2013-2015 being 0.17 kg/tow (0.37 lbs, Sosebee *et al.*, in prep). Average length has decreased from a high of 63 cm (24.8 in) in 1971 to a low of 23 cm (9.1 in) in 2003, but has been stable in recent years at 40-50 cm (15.7-19.7in). Over the same time period, minimum swept-area abundance and biomass estimates decreased from a high of 36,393 mt and 10.9 million individuals in 1966's autumn survey to a lows of 365 mt and 518,900 individuals in autumn 2012 and 499 mt and 485,000 individuals in autumn 2013. Spring survey numbers have followed a similar trend (see Figure 2). Additionally, surveys from 2014-2015 have shown an increase from these lows, with a total of 1,264 mt and 865,000 individuals observed in spring 2015 and 844 mt and 628,000 individuals estimated in autumn 2015.

In addition, the low efficiency of the gear in capturing skate for these surveys (as described above) indicates minimum abundance and biomass in the survey area are higher than numbers reflect. Edwards (1968) estimates the catch efficiency of thorny skate in the NEFSC trawl survey at 0.1, indicating the 2015 survey represents an estimated 8.440 mt and 6 million fish within U.S. waters surveyed by NEFSC (Sosebee *et al.* in prep).

Additional State Surveys

Additional surveys in shallow water have shown similar patterns regarding trends of thorny skate, or have fluctuated without trend.

Massachusetts Division of Marine Fisheries (MADMF) surveys inshore state waters in spring and autumn. Catch of thorny skate is variable in this survey but demonstrates a decreasing trend in thorny skate biomass. Spring surveys have stabilized at rates around 0.2 kg (.44 lbs) per tow. Autumn surveys have been below the median of 0.6 kg/tow (1.3 lbs) for most years since 1994. Average length in this survey is variable but trends toward smaller fish (Sosebee *et al.*, in prep).

The Maine-New Hampshire Inshore Trawl Survey was established in 2000. This survey is stratified by depth and demonstrates low abundance in the inshore area with little trend over the time series (Sosebee *et al.*, in prep).

The Atlantic States Marine Fisheries Commission shrimp survey samples deeper offshore waters within the Gulf of Maine. A decreasing trend is evident here in both abundance and biomass. Although average length has varied considerably over the time series (1985-2015), in general it does not show a decreasing trend (Sosebee *et al.*, in prep).

Thorny Skate

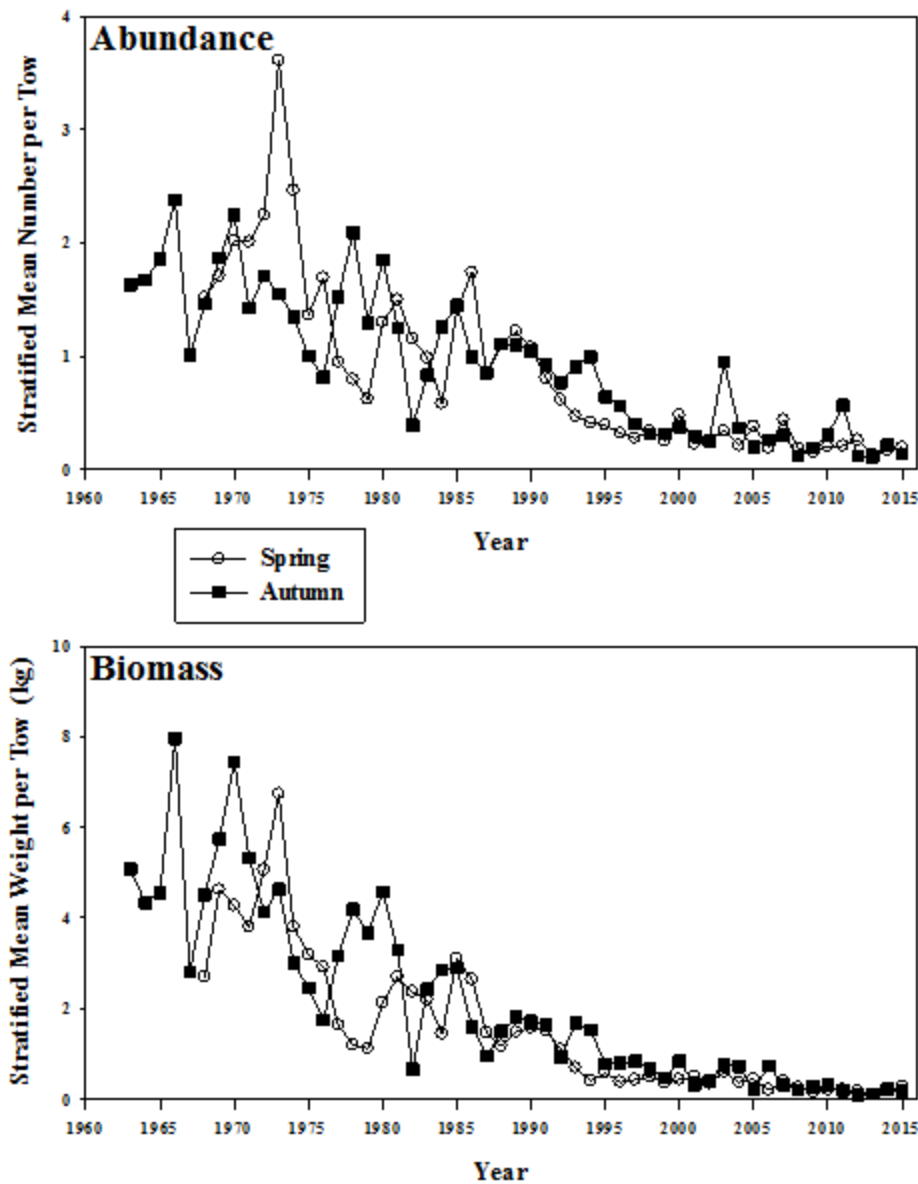


Figure 2. Abundance and biomass of thorny skate from the NESFC spring (circles) and autumn (squares) bottom trawl surveys from 1963-2015 in the Gulf of Maine to Southern New England offshore region. (From Sosebee *et al.*, in prep.)

Canadian Waters

Where data are available, a decrease in abundance has been observed since the 1970s in Canadian waters. Thorny skate are widely distributed and are the most common skate species in Canadian waters. The amount of decrease varies widely between different regions, varying from 30 percent on the Southern Labrador Shelf to more than 80 percent on the Scotian Shelf between 1977 and 2010 (COSEWIC 2012). Over the same time period, all fisheries on the Scotian Shelf decline from 41-51 percent with the larger decline being on the eastern portion of the shelf

(Zawnenburg 2000). Most Canadian areas saw a decline in abundance of thorny skate between 50-60 percent during this time period (COSEWIC 2012).

Since the 1990s, survey abundance has been mostly stable on the Southern Labrador Shelf and Northern Gulf of St. Lawrence, and has increased 61 percent on the Grand Banks (COSEWIC 2012). More recent information was available for the Grand Banks region, where a fishery persists for skates. Biomass in some subdivisions has been increasing, but overall abundance and biomass remains at low levels (DFO 2013). Biomass overall on the Grand Banks has been stable since 2006 (Simpson *et al.* 2016, Nogueira *et al.* 2015)

Overall declines in abundance have been higher for larger skates (COSEWIC 2012). In Canadian waters around Newfoundland, mortality for the smallest skates has declined since the 1970s, while mortality has increased for older juveniles and adults in the Gulf of St. Lawrence (Swain *et al.* 2013). Fishing effort in the area has declined over the same period, suggesting natural mortality factors (not attributable to fishing) are responsible. On the Grand Banks, average length has actually increased since the 1990s (Nogueira *et al.* 2015). Recruitment rate has also increased in the Southern Gulf of St. Lawrence since the 1970s (Benoit and Swain 2011).

Despite the overall downward trend in abundance within Canadian waters throughout the entire time series, the trends since the mid to late 1990s have been stable and increasing in the recent years and thorny skate remain numerous. Estimated minimum abundance for Canada in 2010 was more than 188 million individuals (Table 1) and the true number is likely much higher. Approximately 30-40 percent of the species' range lies within Canadian waters (COSEWIC 2012).

Region	NAFO Division	Years	Minimum estimated abundance (in millions)
Davis Strait	0	1999 only	1.5
North Labrador Shelf	2 GH	1977-1999	24.2
South Labrador Shelf and Newfoundland Shelf	2J3K	2007-2009	19.4
Grand Banks	3LNOPs	2007-2009	79.1
Northern Gulf of St. Lawrence	4RS (no 3Pn)	2008-2010	40.5
Southern Gulf of St. Lawrence	4T	2008-2010	1.6
Scotian Shelf	4VWX	2008-2010	21.7
Georges Bank	5Z Canadian portion only	2008-2010	0.4
Total			188.5

Table 1. Estimated abundance of thorny skate in millions of individuals for different regions in Canada summarized from COSEWIC 2012.

Northeast Atlantic

Thorny skate are widely distributed and are the most common skate species in the Northeast Atlantic. Within the Barents Sea, the population was estimated to average 143 million fish and 95,000 mt of biomass over 1998-2001 (Dolgov *et al.* 2005a). In Norway, their numbers fluctuated without trend between 1992 and 2005. They remain the most widely occurring skate species with a mean catch rate in Norwegian waters of 55.2 per km² (Williams *et al.* 2008). While not directly comparable given differences in tow length and capture efficiency of different gears, this is relatively high when compared to capture rates in Canada and the U.S. In Iceland and East Greenland, population estimates are not available but abundance in groundfish surveys has remained stable since 2000. Area occupied has likewise remained stable, averaging 50 percent from 2000-2014 (ICES 2015).

In the North Sea off the coast of Scotland, thorny skate comprise eighty percent of the total skate biomass (Walker and Heeseen 1996, Piet *et al.* 2009). Biomass was estimated to be greater than 100,000 tons during the early 1980s (Sparholt and Vinther 1991). Abundance of thorny skate in the area increased greatly when compared between 1906-1909 and 1990-1995 time periods, despite the overall decrease in landings of skates and rays in this region over the same time period (Walker and Hislop 1998). Abundance has since decreased again but is comparable to that observed during the 1970s (ICES 2015).

Populations are considered stable throughout their range in the Northeast Atlantic (ICES 2015).

Area occupied in the Northwest Atlantic

Some evidence suggests a contraction of the thorny skate's range over time. In Canadian waters, area occupied has remained stable through much of the species range. Populations off Labrador, north of Newfoundland and on the St. Pierre Bank have all remained stable. More southern areas have experienced a decline in area occupied. On the Grand Banks, area occupied has decreased approximately fifty percent from a high of almost 60,000 km² (17,500nm²) to approximately 30,000 km² in 2010 (8,500nm², COSEWIC 2012). It appears fish in this area have been avoiding colder waters present on the top of the bank, instead moving towards the warmer edge (Kulka and Miri 2003). In the Southern Gulf of St. Lawrence, area occupied has decreased from about 55,000 km² (16,000 nm²) in the mid-1970s to approximate 20,000 km² (5,800nm²) in 2010. Meanwhile, within the Northern Gulf of St. Lawrence, area occupied has doubled from 42,300 km² (12,300nm²) from 1991-1993 to 90,400 km² (26,400nm²) from 2008-2010 (COSEWIC 2012).

On the Scotian Shelf, area occupancy has declined steadily over the time series, by 58% since 1970-1972, and 66% since 1974-1976 (when it occupied 150,000km² /43,700nm²). The decline ceased in 2000 and skate in this area now occupy approximately 50,000 km² (14,600 nm²). There is a strong correlation in this location between area occupied and abundance (Shackell *et al.* 2005), indicating that remaining skates are using the most suitable habitat. Thorny skate occupancy has also declined on the Canadian side of Georges Bank by about 40%. Overall, area occupied for all areas surveyed off Canada (averages for 2007-2009) is approximately 290,000 km² (84,600nm²), about 90,000 km² (26,200nm²) less than in the 1970s. Most of the decline occurred prior to 1991 with the largest decrease on the Scotian Shelf (COSEWIC 2012).

Within the U.S., NEFSC bottom trawl surveys show an approximately 75% decrease in number of total tows containing skate from 1965 to a low in 2008. There is an upward trend in the number of positive tows since 2008. Multiple estimates of biomass and abundance versus area also show a moderate increase in concentration of fish (Sosebee *et al.*, in prep).

One such estimate is the design-weighted area of occupancy, which compares proportion of positive tows to area swept. This measure likewise declined over time, from a high of almost 250,000 nm² (858,000km²) in the mid-1970s to 4-5,000 nm² (14,000-17,000km²) in 2008. Area occupied has increased recently but concentrations of thorny skate remain within the Gulf of Maine (Figure 3, Sosebee *et al.*, in prep). Overall, measures of area occupied have decreased by about half over the species range in the Northwest Atlantic, with a slightly higher decrease on the Scotian Shelf.

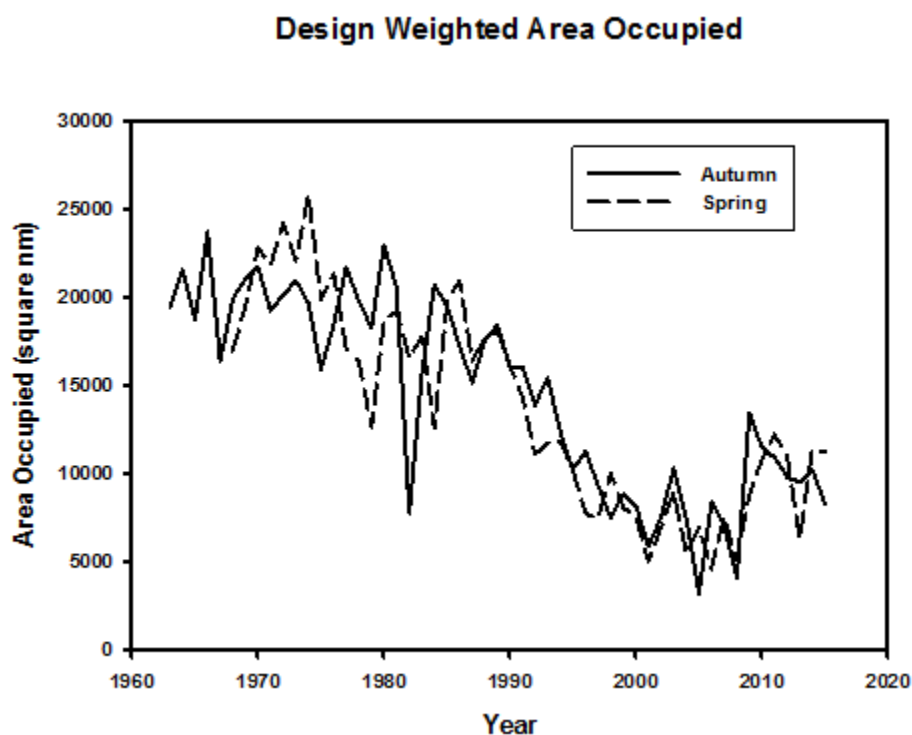


Figure 3. Design-weighted area occupied of thorny skate in the spring and autumn NEFSC surveys (from Sosebee *et al.*, in prep).

Summary of Abundance and Trends

Like many fish species within the Northwest Atlantic, abundance of thorny skate has declined since the highs of the 1970s. The areas of greatest decline have been along the southern portion of their range, including U.S. waters and Canadian waters of the Scotian shelf. Abundance has declined up to eighty or ninety five percent in these areas, although recent surveys show the number of thorny skate in these areas are stable or slightly increasing. In more northern parts of the range, decline in abundance has been closer to sixty percent on average and recent surveys show the number of thorny skate in these areas are increasing or stable

Biomass has also decreased, in part due to decreased abundance but also due to high average adult mortality. Recent biomass estimate indicate stabilization (at low levels) or increasing trends in some regions. Thorny skate remain numerous throughout the greater portion of their range, numbering in the hundreds of millions. Due to low catchability, the species may be even more numerous than estimates predict. Area occupied has declined by approximately half since the 1970s; however, some expansion of area occupied has been observed recently between highs in the 1970s and current estimates but have demonstrated an upward trend in recent years.

ANALYSIS OF THE ESA SECTION 4(A)(1) FACTORS

The ESA requires NMFS to determine whether a species is endangered or threatened because of any of the factors specified in section 4(a)(1) of the ESA. The following provides information on each of these five factors as they relate to the current status of the thorny skate.

Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

The ESA requires an evaluation of any present or threatened destruction, modification, or curtailment of habitat or range. Global climate change may impact the habitat of the thorny skate.

Climate change within the range of the thorny skate

Within the Northwest Atlantic, the species' range from Greenland south is a mixing zone for different currents. The Labrador Current flows down the inner shelf, bringing cooler and fresher water from the north, which flows down over the ocean shelves, including the Grand Banks, Scotian Shelf, Georges Bank and into the Gulf of Maine. Meanwhile, the Gulf Stream in deeper offshore waters brings warmer, saltier water up from the south (Saba *et al.* 2015). The range of the thorny skate covers both of these currents and the mixing zone, thorny skate are able to occur throughout this area due to their tolerance of different temperatures. This mixing zone makes it difficult to predict the impacts of climate change within the area, although recent specific modeling suggests that the Gulf of Maine will warm nearly three times as fast as other areas from a predicted northward shift in the Gulf Stream (Saba *et al.* 2015). Recently the Labrador Current has had the opposite effect, decreasing salinity in the shallower parts of the Gulf of Maine and cooling temperatures on the shelves (Townsend *et al.* 2010). Overall, waters within the range of the thorny skate are expected to get warmer, increase in salinity and decrease in pH (Saba *et al.* 2015). In marine ecosystems, climate change impacts like these are generally expected to push species distribution northward (Frumhoff *et al.* 2007) but possible effects on thorny skate are unclear.

Recent climate impacts observed on thorny skate

In U.S. waters, thorny skate have experienced a relatively high amount of range contraction as measured during NEFSC surveys (as described in DISTRIBUTION AND ABUNDANCE). A small but statistically significant northward shift in range and increased concentration in deeper waters has been detected (Nye *et al.* 2009). A possible explanation of the consistent, long-term decline of thorny skates in the NEFSC trawl survey is skates are shifting out of the survey area. The shift in area occupied on the Grand Banks in Canada may also be a response to climate change. In this area, skates have shifted to the warmer edge of the banks, avoiding the cooler temperatures present on the center of the banks (Kulka and Miri 2003) created by the Labrador Current. The lack of skates present in temperatures below 1 or 2° C (as described in RANGE AND HABITAT USE) supports this conclusion.

There is no information regarding the impacts of ocean acidification on thorny skate. However, a study on the sympatric little skate, *Leucoraja erinacea*, demonstrates that changes in temperature and acidic concentration can result in complex effects on developmental time, body condition and survival in skate hatchlings (Di Santo 2015). There is currently no information

available on how hypoxia or changes in nutrient composition might impact thorny skate. Given their broad range, generalist feeding habits, and ability to move, localized areas of hypoxia or low prey availability are unlikely to have an impact at a species level.

Since climate changes impacts are expected to shift species distribution northward and impact species diversity, recent studies have focused on the impacts of climate change to fish community assemblages, particularly on species richness and diversity. Some impacts have been observed for “coastal” or shallow water communities (<200 m /656 ft in depth) in the Gulf of St. Lawrence (Tamdrari *et al.* 2014) and Iceland (Stefansdottir *et al.* 2010). In both these studies, thorny skate were found to associate more with the deeper water fish assemblages, which had only minor, if any, impacts from climate change.

There may be some evidence the species is shifting to deeper waters. Thorny skate comprised 7.97 percent of fish in the “coastal” species assemblage (<200m) in early 1990s and only 5.58 percent on average from 2004-2010 in the Gulf of St. Lawrence (Tamdrari *et al.* 2014). In the deeper species assemblage (>200m) they went from 3.71 percent in the early 1990s to 4.52 percent averaged from 2004-2010 (Tamdrari *et al.* 2014). This is a relatively small change for both depths when compared to change for other species, representing half as much decrease in the coastal assemblage as redfish (*Sebastes* spp.) and an order of magnitude less than the decrease in Atlantic cod (*Gadus morhua*). Additionally, thorny skate were most abundant between 100 and 350m (328-1148ft) of depth before climate change became apparent (McEachran and Musick 1975).

Vulnerability of the thorny skate to climate change

Recent climate vulnerability analyses have been performed for fisheries in the Northeast U.S. and for fish assemblages on the Scotian Shelf in Canada. Despite having similar methodologies, these studies came to different conclusions regarding the vulnerability of thorny skate to climate change. Stortini *et al.* 2015 rated the vulnerability of thorny skate on the Scotian shelf as “low”. This study scaled the estimated vulnerability relative to thirty-two other species found on the Scotian Shelf, therefore the “low” vulnerability rating is in relation to other species in that location.

Hare *et al.* (2016) rated this species as having a “high” biological sensitivity and climate exposure likelihood off the Northeast U.S., on a scale of “low” to “very high”. In this study, vulnerability was equated to the likelihood of the species experiencing either reduced productivity or shifting its distribution out of the region in response to climate change. This vulnerability analysis concluded that there was also a “high” chance of negative impacts and changes in species distribution within its U.S. range. Both studies used a similar variety of species life history factors to produce a species sensitivity score, but Hare *et al.*, (2016) used a larger variety of climate factors including pH, salinity, precipitation and ocean currents to determine climate exposure, whereas Stortini *et al.* (2015) looked only at mean temperature under different warming scenarios.

The factors responsible for the “high” vulnerability rating included: stock status within the Northeast U.S. (which is overfished), rate of population growth (which is slow), and exposure to temperature and ocean acidification (which is high). All other factors regarding life history and

climate exposure for thorny skate were considered resulting in a “low” predicted vulnerability score (Hare *et al.* 2016).

It is likely that throughout most of the range, the generalist habitat requirements of thorny skate (as summarized in LIFE HISTORY AND ECOLOGY) will limit impact of climate change. This conclusion is supported by studies on species diversity that indicate impacts to species assemblages have not yet occurred on communities including thorny skate, due to their depth preferences (Stefansdottir *et al.* 2010, Tamdarai *et al.* 2015). In addition, modeling predicts a less than 10 percent loss of thermally appropriate habitat before 2030 in U.S. waters, but almost no habitat loss before 2030 in Canadian waters. A ten percent loss is expected in Canada and up to 25 percent loss in U.S. waters may occur before 2060 (Shackell *et al.* 2014). Although the risk may be high for thorny skates to shift their distribution out of Northeast U.S. waters due to warming ocean conditions (Hare *et al.* 2016), the species would have the ability to persist in adjacent regions with more suitable habitat.

Conclusion

There is limited evidence of significant present or threatened destruction, modification, or curtailment of the thorny skate’s habitat or range throughout the Northwest Atlantic due to climate change. The species is likely to be impacted by climate change, with temperature preferences keeping it in deeper waters and potentially causing a northward range shift. However, the best scientific information currently indicates these impacts have been minor up to this point and will remain limited, if slightly higher within U.S. (more southern) waters over the foreseeable future. Additionally, given the generalist nature of the species, thorny skate may still continue to use habitat even if it becomes sub-optimal.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

The ESA contains no guidance on how to assess overutilization, nor does it outline levels of population decline relative to an endangered or threatened status. For the purposes of this status review, population dynamic characteristics, such as current population size, abundance trends by regions, recruitment and dispersal, and the effects of fishing on the population were considered for evaluating the status of the species. Recreational landings of skates are considered very low throughout the range (COSEWIC 2012, Sosebee *et al.* in prep) and no evidence suggests thorny skate are targeted for scientific or educational purposes, so discussion will focus on the impacts of commercial fishing.

Thorny skate were and are taken as bycatch by fisheries throughout their range, including those in the North Sea, Barents Sea, Gulf of St. Lawrence and on the Canadian and U.S. continental shelves. Targeted fisheries, particularly by foreign fleets including those of Spain, Portugal and Russia, developed in the 1990s (COSEWIC 2012, Sosebee *et al.* in prep). The fishery for thorny skate was largely unregulated in the Northwest Atlantic until the 2000s (COSEWIC 2012). Currently small fisheries exist in the North Sea (Piet *et al.* 2009) and on the Grand Banks in Canada (Simpson *et al.* 2016), which is, as mentioned earlier, the first regulated skate fishery in international waters. Since 2003, U.S. vessels have been prohibited from possessing or landing thorny skates (NEFMC 2009). While directed fisheries on the species are currently limited, thorny skate continue to be taken as bycatch and discarded in commercial fisheries

within their range.

Factors that impact thorny skate discard survival in trawl fisheries include size, depth of capture, difference in temperature between bottom and surface conditions (Benoit *et al.* 2013), duration of the tow and degree of injury sustained during the capture event (Mandelman *et al.* 2013). Skates can have an overall high survival rate following discard, with as much as eighty percent survival predicted for trawl fisheries within the Gulf of St. Lawrence (Benoit 2013). Within the Gulf of Maine, short-term mortality for trawl fisheries was estimated at 23 percent at 72 hours after capture. However, mortality increased to 54 percent at seven days after capture (Mandelman *et al.* 2013). Taking these factors into consideration, the following summary of bycatch numbers can be considered an overestimate of mortality.

U.S. Fisheries Catch and Bycatch

Total skate landings for all species within U.S. waters reached 9,400 mt in 1969 and declined after that, reaching a low of 800 mt in 1981. Landings increased substantially after that time period for lobster bait and export, rising to a high of 16,073 in 2004 (Figure 4, Sosebee *et al.* in prep). Estimated total catch of thorny skate has declined from over 5,000 mt in the late 1960s and early 1970s to about 200-300 mt in recent years. Thorny skates make up a small overall portion of skate catch, particularly in comparison to winter and little skates. Most of the early catch was from otter trawl discards while landings dominated the 1990s. Discards from scallop dredges increased in proportion to population estimates during the late 1970s and again during the late 1990s. While landings were generally low, catch of thorny skate likely contributed to the decline of the species over time.

In 2003 the New England Fishery Management Council (NEFMC) implemented a Fishery Management Plan (FMP) for the seven skates present within the Gulf of Maine. The FMP prohibited landings of thorny skate as the stock status was considered overfished (NEFMC 2009). The limited information regarding species biomass required the NEFMC to develop survey-based overfished and overfishing reference points for thorny skate: *Thorny skate is in an overfished condition when the three year moving average of the autumn survey mean weight per tow is less than one half of the 75th percentile of the mean weight per tow observed in the autumn trawl survey from the selected reference time series. Overfishing occurs when the three year moving average of the autumn survey mean weight per tow declines 20% or more, or when the autumn survey mean weight per tow declines for three consecutive Years. The reference points and selected time series may be respecified through a peer reviewed process and/or as updated stock assessments are completed.* The target biomass for thorny skate is currently set at 4.13 kg/tow (9.1 lbs) and the minimum biomass threshold at 2.06 kg(4.5 lbs)/tow. The most recent three-year average remains below these figures at 0.17 kg (0.37 lbs)/tow, however, this figure has remained steady since 2011.

The U.S. Magnuson-Stevens Fishery Conservation and Management Act states: *A stock or stock complex is considered “overfished” when its biomass has declined below a level that jeopardizes the capacity of the stock or stock complex to produce Maximum Standard Yield (MSY) on a continuing basis. MSY is defined as the largest long-term average catch or yield that can be taken from a stock or stock complex.* The overfished/overfishing status of a stock is determined relative to its ability to produce continued yield from a fishery. The overfished status

of thorny skate within the U.S. means that fishing mortality rates (including past landings and discards) have been too high, and caused the population to decline below acceptable levels. The stock must be rebuilt to biomass levels that can produce MSY for a fishery to be sustainable. The prohibition on harvest in U.S. waters is expected to help the stock rebuild. This means any thorny skate caught within U.S. waters must be discarded at sea.

Estimated thorny skate discards are low relative to other skates (Figures 4 and 5). In recent years, Landings and dead discards have decreased in recent years (2007-2014) and total discards have stabilized or increased. However, the overfished condition of thorny skate within U.S. waters likely persists due to the slow reproductive rate and recovery potential of the species as described in REPRODUCTION, GROWTH AND DEMOGRAPHY.

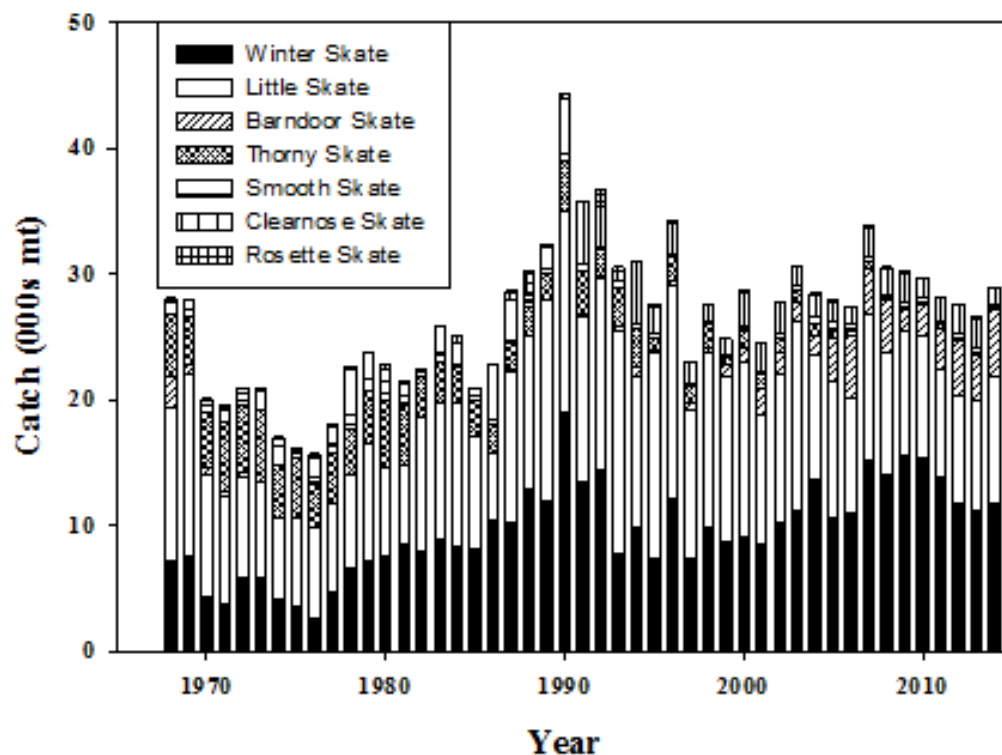


Figure 4. Catch (landings plus dead discards) in U.S. waters by species from 1968-2014. From Sosebee *et al.* in prep.

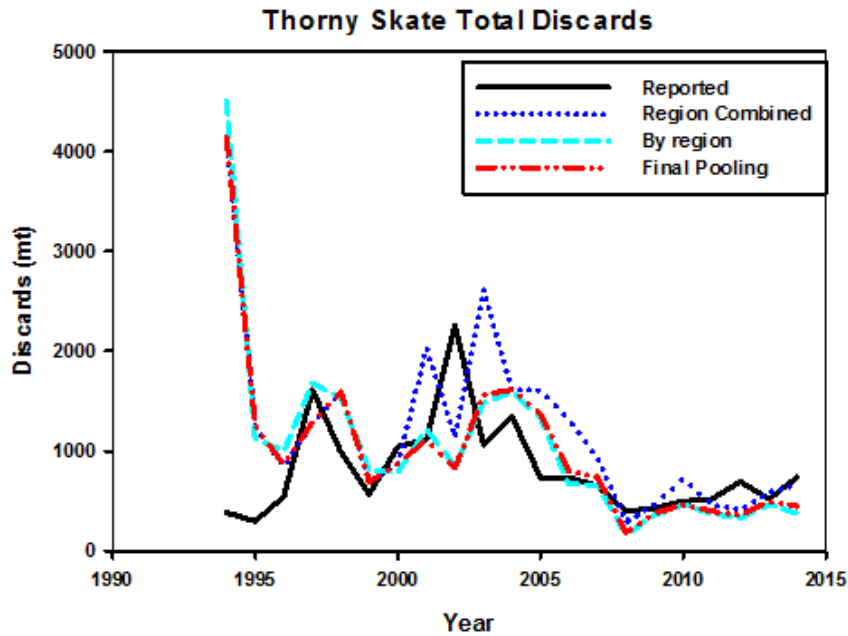


Figure 5. Comparison of total thorny skate discards by observed species and using three different methods. From Sosebee *et al.* in prep.

Canadian Fisheries and Bycatch

Thorny skate comprise the majority of skates caught in commercial fisheries in Canada. The majority of thorny skate catch comes from the coast of Labrador and Newfoundland, including the Grand Banks area. This has ranged from a high of approximately 24,000 mt in the early 1990s to current levels around 6,000 mt (Figure 6). Relative fishing mortality has remained stable in this area at approximately ten percent (COSEWIC 2012).

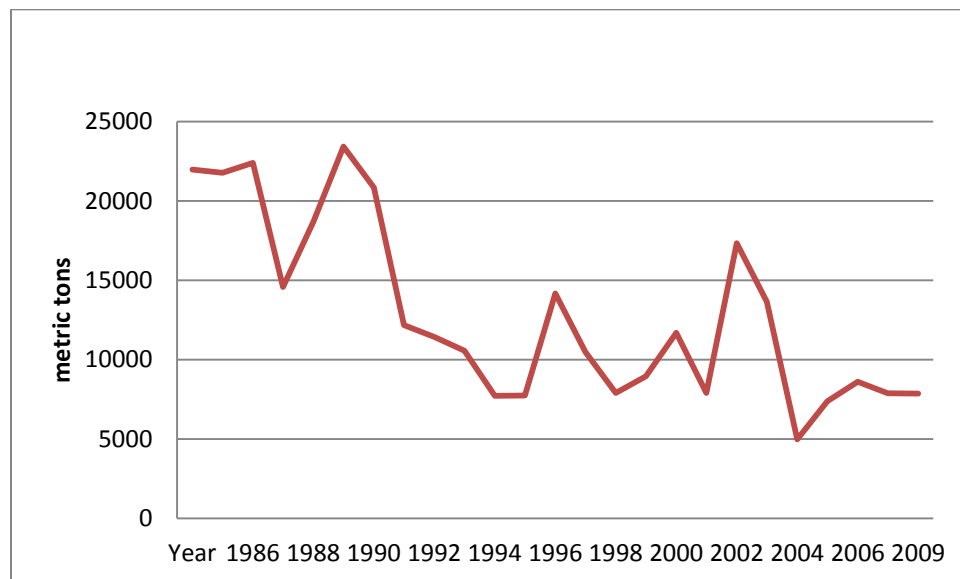


Figure 6. Estimated catches (landings plus discards, in metric tons) of various skate species in Canadian and non-Canadian waters of NAFO Divisions along the Canadian Coast. Approximately 90 percent of these landings are

estimated to be thorny skate. Adopted from COSEWIC 2012.

Within the southern Gulf of St. Lawrence, estimated landings of thorny skate peaked in 1994 at approximately 38 tons, and have since decreased to an average 1-2.7 tons. Thorny skate is the most common discarded skate species. On average, 490 tons were discarded in the early 1990s, this dropped to 53.7 ton on average over the 2006 -2011. While the majority of discards in the past came from trawl fisheries, currently half are from trawl and half from the gillnet fishery for Greenland halibut (Benoit 2013). Overall fishing effort in this area has decline or remained stable since the 1990s(COSEWIC 2012).

The only remaining directed fishery for thorny skate is executed within the Grand Banks Area. This area is managed between two areas, 3Ps directly south of Newfoundland and entirely within the Canadian Exclusive Economic Zone (EEZ), and divisions 3LNO which comprise the outer banks, some of which lies outside the Canadian EEZ. Quota regulation within the EEZ was enacted in 1995 (Simpson *et al.* 2014). In 2004 the Northwest Atlantic Fisheries Organization (NAFO) enacted quota regulation for the entire 3LNO area, make this the first regulated skate fishery in the world in international waters. The regulated areas include areas within and without the Canadian EEZ; 3Ps remained under Canada's quota system. For most years since the quotas were enacted, catch has remained well below the limits (see Figure 7). Relative fishing mortality within the Grand Banks has decreased over time. Within the 3LNO it increased from the late 1980s to a peak of 29 percent in 1997; then stabilized at approximately 17 percent during 1998-2004. In 2005, relative fishing mortality declined to 4 percent and has remained around 5 percent since then. Since 1985, fishing mortality within 3Ps was relatively constant, below 5 percent for most years (Simpson *et al.* 2016).

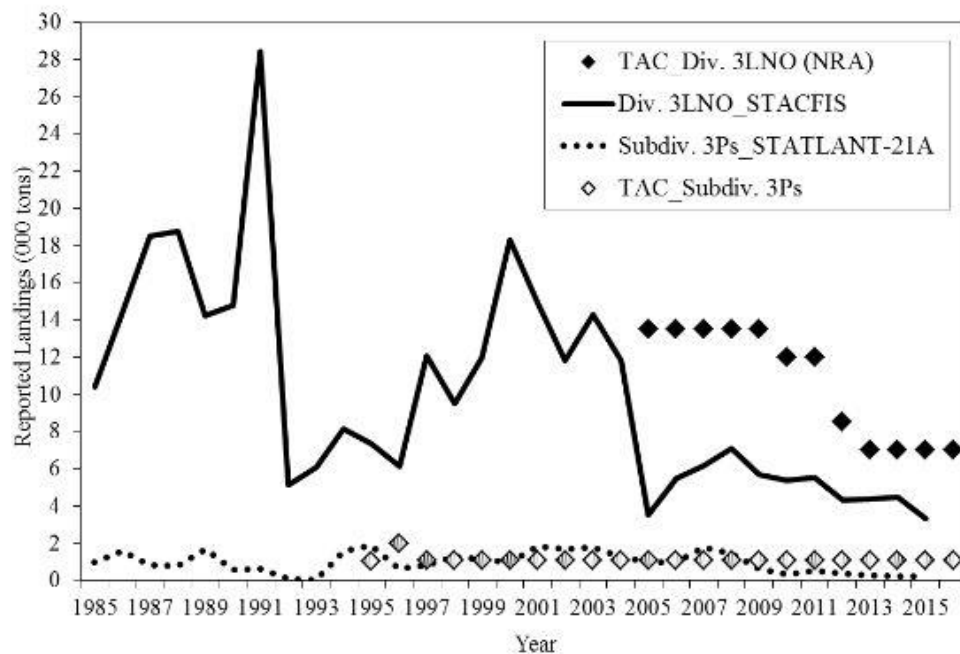


Figure 7. Total reported landings and Total Allowable Catch (TAC) of Thorny Skate, split by divisions with Canada's Grand Banks region. From Simpson *et al.* 2016.

Northeast Atlantic Fisheries and Bycatch

There is little directed effort on thorny skate across most of the Northeast Atlantic, with a prohibition against landings currently in place in European Union waters in the Barents Sea and east of the United Kingdom (ICES 2015). There is a small fishery landing thorny skate from Iceland and Greenland (Figure 8). Landings here have increased but still remain below 2000 mt, or about half that of Canada's yearly landings.



Figure 8. Landings of thorny skate reported from Iceland and Greenland from ICES 2015.

Conclusion

The available information indicates that current thorny skate populations are numerous in many areas and that area occupied is increasing. While the portion of the population within the U.S. is not currently capable of sustaining a fishery, fisheries for thorny skate are well-controlled throughout the range. Fishing mortality relative to biomass has decreased across the range through time, and is currently rather low in most areas. Additionally, the discard mortality rates of released thorny skates may be relatively low.

Disease or Predation

The ESA requires an evaluation of disease and predation factors on thorny skate. Egg capsules for the species are reportedly preyed upon by halibut, Greenland shark and goosfish (Collette and Klein-MacPhee, 2002). Gastropods may also predate on egg cases, with a predicted predation frequency ranging from four to eighteen percent (Cox *et al.* 1999).

Skates, including thorny skate, are prey for a number of species: flounder, other skates, seabirds, marine mammals, shark, cod and other large demersal fishes, with the last being the most important (Morissette *et al.* 2006). Overall mortality for small skates has decreased while increasing for larger skates since the 1970s. Currently, recruitment for smaller skate remains high in portions of the Canadian range (Benoit and Swain 2011, Swain *et al.* 2013). Meanwhile, the numbers of large fishes have decreased. Fishing pressure has also decreased, and substantially some regions, indicating sources of adult skate mortality may be natural. Marine mammal predation, particularly by grey seals, has been suggested as an increasing cause of mortality for some locations (Swain *et al.* 2013).

Thorny skate are at least a minor source of prey for grey seals, composing up to 6 percent of their diet depending on age and season (Beck *et al.* 2007). Grey seal energy requirements are high enough that this predator may be responsible for much of the natural mortality of adult thorny skate in some areas, despite being a minor prey source (Swain *et al.* 2013, Benoit *et al.* 2011). Energetics modeling has been found to explain a similar pattern of increased adult mortality in other local species (Benoit *et al.* 2011). Further modeling work found a negative relationship between the grey seal index and thorny skate numbers in the Southern Gulf of St. Lawrence. The harp seal index was more likely to explain population trends in the Northwest portion of the Gulf. Predation by either species was not found to explain trends in thorny skate within the northeast portion of the Gulf (Ouellet *et al.* 2016).

Predation by grey seals may have increased within the range of thorny skate. Grey seal populations have recovered during the same time period of decreasing mortality for small thorny skate. Numbering only 15,000 individuals in the 1960s, the grey seal population increased to 350,000 by 2007. In 2014 the population estimate within the Canadian range and Gulf of Maine had increased to 505,000 (Hamill *et al.* 2014). In addition, grey seals have been expanding their range and are now present in small numbers as far south as Southern New England (DiGiovanni Jr. *et al.* 2016).

Grey seals stay mostly local (within 50km) to haul-out sites and forage in mostly in shallow depths (~100m) (McConnell *et al.* 1999, Schreer *et al.* 2001). The largest numbers of grey seals are found in the Gulf of St. Lawrence and on Sable Island off the coast of Nova Scotia, where they may impact skate on the Scotian Shelf. Smaller populations are found in coastal Nova Scotia, Seal Island, Maine and on Cape Cod, Massachusetts (Hamill *et al.* 2014). If grey seal predation is contributing to thorny skate mortality, the impact is likely to be concentrated in the shallowest portions of the thorny skate range around major grey seal population areas.

Harp seals migrate to the Gulf of St. Lawrence to whelp before returning to Arctic waters on the overlapping range of thorny skate. They migrate along the coast of Labrador and Greenland northward. Small numbers of harp seals may remain year-round in southern waters, with the majority living in the Arctic. Currently there is no evidence that thorny skate comprise more than an incidental portion of the harp seal diet. Harp seal reproductive rates decreased in the latest assessment, with 8.3 million individuals estimated in 2008 and 7.7 million estimated in 2012 (DFO 2012). Harp seal predation on thorny skate is likely stable or slightly decreasing and centered around whelping sites.

Conclusion

Modeling indicates marine mammal predation may contribute to high natural mortality of adult thorny skate in some discrete areas, suppressing recovery of their populations (DFO, 2012). For now, high levels of recruitment in small skates are still evident despite this pressure. Recent abundance of thorny skate has also been stable in areas where marine mammal populations are centered. The recent population increase of grey seals in U.S. waters and coinciding stabilization of thorny skate abundance indices suggests that seal predation was not likely responsible for thorny skate declines.

Evaluation of the Inadequacy of Existing Regulatory Mechanisms

The ESA requires an evaluation of existing regulatory mechanisms to determine whether they may be inadequate to address threats to the thorny skate. Existing regulatory mechanisms may include Federal, state, and international regulations. Below is a description and evaluation of current domestic and international management measures that affect the species.

U.S. Regulations

Within U.S. waters thorny skate are managed under the Magnuson-Stevens Fishery Conservation and Management Act (MSA). As described in OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES, landings of thorny skate within U.S. waters were unregulated until 2003 when the NEFMC established an FMP for the skate complex. At that time the stock was deemed “overfished” and a landing prohibition was put in place, requiring all catch of thorny skate to be discarded at sea. At that time the same prohibitions were put into place for the sympatric species, barndoor and smooth skates, to help rebuild these stocks. The skate complex FMP does still allow catch of other skate species, and other fisheries may also catch thorny skate but are likewise required to discard them.

MSA regulations are enforced in U.S. waters by the U.S. Coast Guard, NOAA’s Office of Law Enforcement and state partners. Fishermen who do not comply with regulations established under the MSA are subject to fines and other civil and criminal penalties, depending on the severity of the offense. Compliance with the prohibition against landing thorny and other skates was examined via port sampling. In 2005, 3.61 percent of skate wing landings were identified as thorny skate. In the years since, this declined rapidly with less than 1 percent of wings identified as thorny skate in 2007, and further declined to 0.01 percent in 2012, indicating that compliance with the discard regulations and misidentifications or mislabeling is not an issue in the U.S. (Curtis and Sosebee 2015).

While thorny skate is still considered overfished within the U.S., overfishing is no longer occurring (NEFMC 2009), indicating that fishery management measures are successfully controlling fishing mortality in those waters.

Canadian Regulations

As described in OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES, Under the Fisheries Act, Canadian fisheries may take thorny skate as bycatch in other fisheries, and a small directed fishery still operates on the Grand Banks.

Available information suggests that catch is well below the total allowable catch limits as set by NAFO and Canada, indicating fishing mortality is controlled (see figure 7 in Canadian Fisheries and Bycatch, Simpson *et al.* 2016). The Scotian shelf has been closed to directed fishery for skates (thorny and winter) since the early 2000's. In addition to compliance with catch limits, thorny skate abundance has been stable on the Grand Banks and the rest of Canada, yet still below historic levels (COSEWIC 2012), (as described in DISTRIBUTION AND ABUNDANCE). Recruitment in this portion of the species range remains relatively high. Therefore existing regulatory measures appear sufficient to control fishing mortality and suggests that fishing mortality is not the reason for the low observed abundance levels in a pattern similar to that of thorny skates in US waters.

Northeast Atlantic Regulations

As described in OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES, there is a prohibition against landing thorny skate from European Union waters in the Barents Sea and east of the United Kingdom (ICES 2015). A very small fishery exists in Iceland and off East Greenland, where survey numbers have remained stable since 2000 (ICES 2015). With populations within the Northeast Atlantic currently considered stable (ICES 2015), existing regulatory measures appear sufficient to control fishing mortality within this region. Iceland reported 1625t of thorny skate landings in 2014. A 2016 EU regulation prohibits thorny skate landing for EU waters of ICES divisions IIa, IIIa and VIId and ICES subarea IV Subareas II and IV and Division IIIa (Norwegian Sea, North Sea, Skagerrak, and Kattegat), based on ICES advice that a precautionary approach dictates no targeted fishing and measures to reduce bycatch. ICES advice for this species west of the UK is currently pending. Thorny skates taken from these EU waters are counted under a regional EU skate quota that lacks a robust scientific basis. EU limits on these species have been generally trending toward more precautionary over the last decade.

Conclusion

The best available information indicates that legal protections for thorny skate vary between outright prohibitions on landings in the U.S. and much of the Northeast Atlantic, with limited fishing permitted in Canada and Iceland. While thorny skate are also a bycatch species within many fisheries, stable population numbers indicate existing protections are sufficient through much of its range.

Other Natural or Manmade Factors Affecting the Species' Continued Existence

Thorny skate as described in REPRODUCTION, GROWTH AND DEMOGRAPHY are a slow-growing species with a long generation time. Combined with the decreasing trend in population size and area occupied (described in DISTRIBUTION AND ABUNDANCE), thorny skate as a species might be more susceptible to natural stochastic events than some other fish species. Despite the declines in some areas due to fishing effort, current populations are relatively stable. In addition, these factors are balanced by their remarkably broad distribution and generalist life history.

The wide range of habitat, temperatures, depths and diet used by the thorny skate (summarized in

LIFE HISTORY AND ECOLOGY) limits the type of events that might negatively impact the species. It is unlikely that temporary fluctuations in conditions or prey availability will have more than localized impacts. Likewise, the broad range of the species limits the overall threat of stochastic events. While thorny skate is a genetically diverse species (as described in POPULATION STRUCTURE), the highest diversity is located in the central portion of the range (Greenland and Iceland), which indicates there is some genetic mixing. Furthermore, the high genetic diversity means that loss of thorny skate in outlying regions of the range would not have a significant impact on species genetic diversity as a whole. Currently there is no information suggesting that natural stochastic events have had a negative impact on the species. For a discussion of impacts from climate change, see (PRESENT OR THREATENED DESTRUCTION, MODIFICATION OR CURTAILMENT OF HABITAT OR RANGE).

Conclusion

Available information does not indicate that the slow reproduction time of skates is sufficient to make them vulnerable to stochastic events on a species level. Stable population sizes, broad species range and generalist life history requirements all provide some protection against natural stochasticity.

ASSESSMENT OF EXTINCTION RISK FOR THE THORNY SKATE (*Amblyraja radiata*)



Photo: D. Flescher, NOAA Fisheries

National Marine Fisheries Service
National Oceanic and Atmospheric Administration

INTRODUCTION

The Endangered Species Act (ESA) (Section 3) defines endangered species as “any species which is in danger of extinction throughout all or a significant portion of its range.” Threatened species is defined as “any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.” In many previous NMFS status reviews, a team has been convened, often referred to as a “Biological Review Team,” in order to compile the best available information on the species and conduct a risk assessment through evaluation of the demographic risks, threats, and extinction risk facing the species or distinct population segment (DPS). This information has ultimately been used by the NMFS Protected Resources office, after consideration of the legal and policy dimensions of the ESA standards and benefits of ongoing conservation efforts, to make a listing determination. For purposes of this risk assessment, NMFS convened a workshop panel in May 2016 comprised of experts in thorny skate and elasmobranch biology and ecology, fisheries population dynamics, and fisheries management from the NEFSC, GARFO, the New England Fishery Management Council, and two non-governmental organizations (New England Aquarium and Shark Advocates International) to provide NMFS with their individual expert opinions. The workshop participants each reviewed the best available scientific information, reviewed the available information for thorny skate to provide their expert opinions regarding demographic parameters and extinction risk. The panelists also provided individual expert opinions regarding the significance questions outlined in the NMFS Significant Portion of Its Range Policy during a conference call in June 2016.

Documented global extinctions (i.e., complete biological extinction) of marine fish species are extremely rare compared to other marine, terrestrial, and aquatic taxa (McKinney 1998, Carlton et al. 1999, Dulvy et al. 2003, del Monte-Luna et al. 2007). Acknowledging the difficulties associated with detecting extinction in the ocean (Carlton et al. 1999), most marine fishes are considered to have a level of inherent resistance to global extinction, including broad distributions, moderate to high dispersal and/or mobility, compensatory mechanisms, generalist habitat and feeding strategies, in addition to living within a massive, complex, and comparatively inaccessible environment (Musick 1999, Dulvy et al. 2003, del Monte-Luna et al. 2007). Even amongst biologically vulnerable groups such as elasmobranchs, overfishing, habitat loss, pollution, and other anthropogenic disturbances have not resulted in any documented modern global extinctions (Dulvy et al. 2003, del Monte-Luna et al. 2007). However, a number of local extinctions have been documented in elasmobranchs, and there are numerous threats to the persistence and recovery of many depleted populations (Dulvy et al. 2003, 2014). These factors will be considered and discussed as they relate to thorny skate within this ERA.

DISTINCT POPULATION SEGMENT ANALYSIS

Consideration of the Species Question

In determining whether to list a species of fish, the first issue is whether the petition identifies a species, subspecies, or distinct population segment (DPS) for listing. The thorny skate, or

Amblyraja radiata, is a species. The taxonomic breakdown of *A. radiata* is as follows:

Kingdom: Animalia
Phylum: Chordata
Class: Chondrichthyes
Subclass: Elasmobranchii
Order: Rajiformes
Family: Rajidae
Genus: *Amblyraja*
Species: *radiata*

The petition requested that NMFS list either the United States or North Atlantic populations of thorny skate (*Amblyraja radiata*) as DPSs under the ESA.

Criteria for Identification of Distinct Population Segments

The next issue is whether any petitioned populations qualify as DPSs within the species. The joint policy of the USFWS and NMFS provides guidelines for defining DPSs below the taxonomic level of species (61 FR 4722; February 7, 1996). The policy identifies two elements to consider in a decision regarding whether a population qualifies as a DPS: discreteness and significance of the population segment to the species.

Discreteness

A DPS may be considered discrete if it is markedly separate from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors, or if it is delimited by international governmental boundaries. Genetic differences between the population segments being considered may be used to evaluate discreteness.

Significance

If a population segment is considered discrete, its biological and ecological significance must then be evaluated. Significance is evaluated in terms of the importance of the population segment to the overall welfare of the species. Some of the considerations that can be used to determine a discrete population segment's significance to the taxon as a whole include:

- 1) Persistence of the population segment in an unusual or unique ecological setting;
- 2) Evidence that loss of the population segment would result in a significant gap in the range of the taxon; and
- 3) Evidence that the population segment differs markedly from other populations of the species in its genetic characteristics.

Distinct Population Segment Analysis

Proposed DPSs by Petitioners

NMFS received a petition requesting that we list thorny skate as either Northwest Atlantic or United States Distinct Population Segments (DPS) under the ESA, as well as designate critical habitat for the species.

Evaluation of DPSs

To be inclusive, NMFS is evaluating whether or not any DPSs, not just a Northwest Atlantic or U.S. DPS, exist throughout the entire range of the thorny skate. As discussed in the Status Review section on **Population Structure**, tagging and genetics data, as well as fisheries management information, are available with which to make determinations about potential DPSs.

Thorny skate are widely distributed across the Northern Atlantic, without any significant known gaps in the species range (COSEWIC 2012). Potential for depth and distance to become a barrier exists, but currently it is unknown whether any such barriers exist across the Northern Atlantic and therefore thorny skate are assumed at this time to be contiguous. Likewise populations are considered contiguous between the U.S. and Canada.

Conventional tagging data suggest that individual movement is limited (Templeman 1984, Walker *et al.* 1997), however, tagging studies to date have been small and relied upon recapture of individuals by fishing operations. There is a lack of information regarding species' movements in deeper water. However, the long distance movements of some tagged individuals (100s of km) suggest that occasional large movements by some individuals may be sufficient to promote reproductive mixing across the species' range (Templeman 1984, Chevolut *et al.* 2007). There are no physical barriers to thorny skate migration and migratory pathways appear to be present between all ocean basins.

As highlighted in the DPS Policy, quantitative measures of morphological discontinuity or differentiation can serve as evidence of marked separation of populations. No genetic difference was detected between thorny skate caught within Canadian versus U.S. waters (Tsang *et al.* 2008). Best available genetic information suggests a significant amount of genetic diversity between populations in the Northwest and Northeast extremes; however no significant difference is found when individuals from the center of the range are included. Genetic mixing may also be occurring in the center of the range (Lynghammar *et al.* 2014). The center of the species range around Iceland and Greenland contains the highest amount of genetic diversity, with the edges of the species range in the Northwest and Northeast Atlantic both having lower levels of diversity. We do not know if the diversity is in neutral genetic markers or is indicative of adaptation. It should be noted that Lynghammar *et al.* (2014) was not specifically targeting thorny skate, therefore improved sampling for thorny skate is suggested for future research. However, this study represents the best available scientific information on thorny skate genetics. In summary, current information indicates thorny skates in the Northwestern Atlantic comprise a single stock, despite the differences in length and length at maturity. Some genetic differentiation is present between the Northwest Atlantic and Northeast Atlantic, but the central portion of the range appears to bridge diversity between these two areas. This is likely made possible by the continuous distribution and depth range of the species.

Morphological differences in thorny skate populations are limited to body size and age at maturity. Comparisons of individuals of different sizes from two sites in the Gulf of Maine and two sites in Canadian waters found no significant genetic differences (Tsang *et al.* 2008). Comparison of "late maturing" skates collected mostly north of Newfoundland and "early maturing" skates collected within Canadian waters south of Newfoundland also found no

significant differences (Lynghammar *et al.* 2014). There do not appear to be any populations that are markedly separate morphologically.

A population can be determined to be discrete if it is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the ESA. For thorny skate, fishing is permitted in the central portion of the species' range comprising the area of the Grand Banks in Canadian waters, as well as Iceland and Greenland. Meanwhile landings of thorny skate are prohibited in the extreme west (U.S.) and east (U.K. eastward) portions of the species range. Most shallow water areas across the species range undergo some form of fishing mortality as thorny skates are a common bycatch species. There are some differences in management in the Northwestern Atlantic (by NAFO) and the Northeastern Atlantic (by ICES). While we acknowledge there are regulatory differences for thorny skate, the management differences do not rise to level of discreteness for DPS determination purposes as the species is generally managed as a whole throughout its range.

Thorny skate are habitat generalists. None of the populations appear to occur in an ecological setting unusual or unique for the taxon. The loss of thorny skate in the Northwest Atlantic or Northeast Atlantic would result in a significant gap in the range of a taxon, at least in the short term until dispersal resulted in recolonization. Thorny skate are well distributed throughout the Atlantic; there is no population that represents the only surviving natural occurrence of the taxon. Thorny skate do not exist as an introduced population outside its historical range.

Because we do not find any populations that are discrete, we do not go on to the second prong of the DPS criteria (significance). Therefore, based upon the best available data, NMFS instructed the workshop participants to provide individual expert opinion related to the extinction risk of thorny skate rangewide.

EXTINCTION RISK ANALYSIS

Often the ability to measure or document risk factors is limited, and information is not quantitative and very often lacking altogether. Therefore, in assessing risk, it is important to include both qualitative and quantitative information. In previous NMFS status reviews, Biological Review Teams have used a risk matrix method to organize and summarize the professional judgment of a panel of knowledgeable scientists. This approach is described in detail by Wainright and Kope (1999) and has been used in a number of status reviews (see <http://www.nmfs.noaa.gov/pr/species/> for links to these reviews). In the risk matrix approach, the condition of the species is summarized according to four demographic risk criteria: abundance, growth rate/productivity, spatial structure/connectivity, and diversity. These viability criteria, outlined in McElhany et al. (2000), reflect concepts that are well-founded in conservation biology and that individually and collectively provide strong indicators of extinction risk. Using these concepts, we asked the workshop participants to individually estimate the extinction risk of the thorny skate after conducting a demographic risks analysis. Likewise, we asked the workshop participants to individually assess threats to the species by scoring the severity of current threats to the species as well as predicting whether the threat will increase, decrease, or

stay the same in the foreseeable future. The summary of the demographic risks and threats obtained by this approach was then considered by workshop participants when individually determining the species' overall level of extinction risk. Specifics on each analysis are provided below.

Methods

Foreseeable Future

The “foreseeable future” describes the extent to which the Secretary can, in making determinations about the future conservation status of the species, reasonably rely on predictions about the future (Department of the Interior Solicitor’s Memorandum M-37021, “The Meaning of ‘Foreseeable Future’ in Section 3(20) of the Endangered Species Act”(Jan. 16, 2009)). Those predictions can be in the form of extrapolation of population or threat trends, analysis of how threats will affect the status of the species, or assessment of future events that will have a significant new impact on the species. Consideration should be given to the life history of the species, habitat characteristics, availability of data, kinds of threats, ability to predict threats and their impacts, and the reliability of models used to forecast threats over that “foreseeable future” in determining the time period that constitutes the foreseeable future. This approach does not limit the time frame under consideration to the length of time into the future for which a species’ status can be quantitatively modeled or predicted within predetermined limits of statistical confidence, but uncertainties of any modeling efforts should be documented. Furthermore, because a species may be susceptible to a variety of threats for which different data are available, or which operate across different time scales, the foreseeable future may not necessarily be reducible to a particular number of years. Regardless, a single, numerical “foreseeable future,” several numerical “foreseeable futures” for different relevant threats, or a non-numerical “foreseeable future” should be defined early in the status review process, and a strong rationale for identifying a particular “foreseeable future” should be documented in the Status Review Report.

With these caveats in mind the foreseeable future for this extinction risk analysis was considered to extend out to several decades. Given the species’ life history traits, with longevity estimated to be up to 40 years, maturity around 11 years and generation time estimated to be around 16 years it would likely take more than a decade (i.e. multiple generations) for any recent management actions to be realized and reflected in population abundance indices. Furthermore, as one of the potential threats to thorny skate is climate change, current climate models are considered reliable to 2055, after which many of the models diverge. After discussion of the life history and ability to predict threats facing thorny skate, the thorny skate workshop participants used a thorny skate foreseeable future of 40 years.

Demographic Risk Analysis

After reviewing all relevant biological and commercial information for the species, including: current abundance of the species in relation to historical abundance and trends in abundance based on indices such as catch statistics; the species growth rate/productivity in relation to other species and its potential effect on survival rates; its spatial and temporal distribution; natural and human-influenced factors that cause variability in survival and abundance; and possible threats to genetic integrity; the workshop participants individually assigned risk scores to each of the four

demographic criteria (abundance, growth rate/productivity, spatial structure/connectivity, diversity). Risks for each demographic criterion were ranked on a scale of 1 (no or very low risk) to 5 (very high risk). Below are the definitions that the workshop participants used for each ranking:

Very Low Risk (1)	It is unlikely that this descriptor contributes significantly to risk of extinction, either by itself or in combination with other VP descriptors.
Low Risk (2)	It is unlikely that this descriptor contributes significantly to long-term or near future risk of extinction by itself, but there is some concern that it may, in combination with other VP descriptors.
Moderate Risk (3)	This descriptor contributes significantly to long-term risk of extinction, but does not in itself constitute a danger of extinction in the near future.
High Risk (4)	This descriptor contributes significantly to long-term risk of extinction and is likely to contribute to short-term risk of extinction in the near future.
Very High Risk (5)	This descriptor by itself indicates danger of extinction in the near future.

The workshop participants were given a template (Table 2) to fill out and asked to rank the risk of the demographic factors. Preliminary scores were discussed during the Extinction Risk Workshop and then provided back to the workshop participants for consideration and review. During the workshop, panelists provided their individual expert opinions regarding their perspectives for each of the demographic risks including considerations outlined in McElhany *et al.* (2000) and the supporting data on which it was based.

Table 2. Template for the risk matrix used to document individual workshop participant expert opinions. The matrix is divided into four sections that correspond to the parameters for assessing population viability (McElhany *et al.* 2000).

Viable Population Descriptor	Expert	Risk Score (1-5)	Discussion Notes	Individual reviewer Justification- <i>(Provide narrative for your decision making process, including any citations that were relevant to your decision). Also include a narrative of uncertainties you considered with your score.</i>
Abundance				
Growth Rate				
Spatial Structure				
Diversity				

Threats Assessment

Section 4(a)(1) of the ESA requires the agency to determine whether the species is endangered or threatened because of any of the following factors:

- 1) destruction or modification of habitat;
- 2) overutilization for commercial, recreational, scientific, or educational purposes;
- 3) disease or predation;
- 4) inadequacy of existing regulatory mechanisms; or
- 5) other natural or human factors

All six workshop participants conducted an independent, qualitative ranking of the severity of each of the twenty-one identified threats to thorny skates.

Workshop participants ranked the threats for thorny skates at a range-wide scale (*See* Figure 9). The workshop participants adopted the “likelihood point” (FEMAT) method to allow individuals to express uncertainty in determining the contribution to extinction risk of each threat to the species. Each workshop participant was allotted five likelihood points to rank each threat. Workshop participants ranked the severity of each threat through the allocation of these five likelihood points across five ranking criteria ranging from a score of “very low contribution” to “very high contribution.” Below are the specific definitions of the threat effect levels:

Ranking	Definition
(1) Very Low Contribution	It is unlikely that this threat contributes significantly to risk of extinction, either by itself or in combination with other threats.
(2) Low Contribution	It is unlikely that this threat contributes significantly to long-term or near future risk of extinction by itself, but there is some concern that it may, in combination with other threats.
(3) Medium Contribution	This threat contributes significantly to long-term risk of extinction, but does not in itself constitute a danger of extinction in the near future.
(4) High Contribution	This threat contributes significantly to long-term risk of extinction and is likely to contribute to short-term risk of extinction in the near future.
(5) Very High Contribution	This threat by itself indicates danger of extinction in the near future.

Individual workshop participants were given a template (Figure 9) to fill out and asked to rank the effect that the threat was currently having on the extinction risk of the species. Each workshop participant could allocate all five likelihood points to one ranking criterion or distribute the likelihood points across several ranking criteria to account for any uncertainty. Each workshop participant distributed the likelihood points as she/he deemed appropriate with the condition that all five likelihood points had to be used for each threat. Workshop participants also had the option of ranking the threat as “0” to indicate that in their opinion there was insufficient data to assign a score, or “N/A” if in their opinion the threat was not relevant to the species either throughout its range or for individual stock complexes. When a workshop

participant chose either N/A (Not Applicable) or 0 (Unknown) for a threat, all 5 likelihood points had to be assigned to that category only.

The workshop participants were asked to identify other threat(s) or demographic factor(s) that were interacting with to increase the species' extinction risk. After the Extinction Risk Workshop, individual reviewers were instructed to review their individual scores and provide written individual justification.

Listing Factor		Not Applicable N/A	Unknown 0	Very Low contribution to extinction risk 1	Low Contribution to extinction risk 2	Moderate contribution to extinction risk 3	High contribution to extinction risk 4	Very High Contribution to extinction risk 5
A) The present or threatened destruction, modification, or curtailment of habitat or range	Climate Change* (see climate guidance)			1	2	2		
	Other manmade non-fishing habitat impacts (e.g. drilling, windfarms)					1	3	1
	Bottom fishing Impacts			5				
	Commercial Landings							
B) Over-utilization for commercial, recreational, scientific, or educational purposes	Commercial Discards							
	IUU Fishing							
	Ghost Fishing							
	Recreational Landings							
	Recreational Discards							
	Scientific Research							
	Educational							
C) Disease or predation	Disease							
	Predation							
	US Fishies Reg.							
	Other global or national environmental regulations							
	Global or National Climate Change Regulations							
	Canadian Fishery Regulations							
	NAFO							
	Northeast Atlantic (e.g. EU, Norway, Iceland, NEAFC)							
D) Inadequacy of existing regulatory mechanisms								
E) Other Natural or man-made factors	Manmade catastrophic events (e.g. Oil spills)							
	Stochastic Events							

Figure 9. Example of qualitative threats assessment worksheet and how likelihood points could be assigned to account for uncertainty (*this example does not represent real data*).

Overall Level of Extinction Risk Analysis

Guided by the results from the demographics risk analysis as well as threats assessment, workshop participants used their informed professional judgment to individually make an overall extinction risk determination for the species now and in the foreseeable future. For these analyses, the workshop participants used three levels of extinction risk defined as:

Rank	Definitions
Low Risk (1)	A species or DPS is at low risk of extinction if it is not at moderate or high level of extinction risk (see “Moderate risk” and “High risk” above). A species or DPS may be at low risk of extinction if it is not facing threats that result in declining trends in abundance, productivity, spatial structure, or diversity. A species or DPS at low risk of extinction is likely to show stable or increasing trends in abundance and productivity with connected, diverse populations.
Moderate Risk (2)	A species or DPS is at moderate risk of extinction if it is on a trajectory that puts it at a high level of extinction risk in the foreseeable future (see description of “High risk” above). A species or DPS may be at moderate risk of extinction due to projected threats or declining trends in abundance, productivity, spatial structure, or diversity. The appropriate time horizon for evaluating whether a species or DPS will be at high risk in the foreseeable future depends on various case- and species-specific factors. For example, the time horizon may reflect certain life history characteristics (e.g., long generation time or late age-at-maturity) and may also reflect the time frame or rate over which identified threats are likely to impact the biological status of the species or DPS (e.g., the rate of disease spread). (The appropriate time horizon is not limited to the period that status can be quantitatively modeled or predicted within predetermined limits of statistical confidence. The biologist (or Team) should, to the extent possible, clearly specify the time horizon over which it has confidence in evaluating moderate risk.)
High Risk (3)	A species or DPS with a high risk of extinction is at or near a level of abundance, productivity, spatial structure, and/or diversity that places its continued persistence in question. The demographics of a species or DPS at such a high level of risk may be highly uncertain and strongly influenced by stochastic or compensatory processes. Similarly, a species or DPS may be at high risk of extinction if it faces clear and present threats (e.g., confinement to a small geographic area; imminent destruction, modification, or curtailment of its habitat; or disease epidemic) that are likely to create imminent and substantial demographic risks.

The workshop participants adopted the “likelihood point” (FEMAT) method to allow individuals to express uncertainty in determining the overall level of extinction risk facing the species (Table 3). Each workshop participant was given the following instructions in their ranking templates: “Distribute 10 likelihood points per person among the three defined levels of extinction risk. In the absence of any information at all about a species or threats to a species, the ‘null hypothesis’ is one where all likelihood points are in the ‘low risk’ category. Specific supporting information must therefore be cited in order to put likelihood points into the moderate and high risk categories and each workshop participant should clearly document the rationale for their individual point distribution. The overall extinction risk determination reflects informed professional judgment by each workshop participant. This assessment is guided by the results of the risk matrix analysis, integrating the best available information about demographic risks (VP descriptors) and specifically discussing threats (section 4(a)(1) factors) with expectations about likely interactions with threats to come to a single overall conclusion on the degree of extinction risk to the species.” In the ERA workshop the panelists provided their individual expert opinions and were given an opportunity after the workshop to revise scores and provide a written individual justification.

Finally, workshop participants did not make recommendations as to whether thorny skate should be listed as threatened or endangered rangewide. Rather, the workshop participants drew scientific conclusions about the overall risk of extinction faced by the species under present conditions and in the foreseeable future based on an evaluation of the species' demographic risks and assessment of threats.

Table 3. Template for the overall level of extinction risk analysis used to document individual workshop participant's expert opinions. Likelihood points were distributed amongst each of the categories based upon each workshop participant's expert judgment.

Overall Extinction Risk	Low Risk	Moderate Risk	High Risk	Individual reviewer Justification- (Provide narrative for your decision making process, including any citations that were relevant to your decision, and how your point distributions accounted for any uncertainties)
	1	2	3	
Reviewer name				

ERA Workshop Results for the Thorny Skate

Evaluation of Demographic Risks

The compiled results of the workshop participants' thorny skate demographic assessments are shown in Table 4.

Table 4. Assessment of demographic risks for thorny skate

Demographic Factor	Mean	Range	Risk
Abundance	1.67	1-2	Very Low to Low
Productivity	2.50	2-3	Low to Moderate
Spatial Structure	1.50	1-2	Very Low to Low
Diversity	1.67	1-2	Very Low to Low

Abundance

The workshop participants individually evaluated the available thorny skate abundance information, which is summarized in the **Description of Population Abundance and Trends** section of the status review. Workshop participants noted that the available information indicated thorny skate abundance had declined significantly from historic levels in certain parts of its range. However, in all regions where abundance trends and/or indicators are available, declines appear to have been halted, and increases in abundance were apparent in some regions.

Further declines are unlikely due to improved management. Abundance estimates from the Northwest Atlantic are currently in the millions of individuals, even where significant declines have occurred. The mean score we calculated based on the workshop participants' scores corresponds to a *Very Low to Low* ranking rangewide, as this factor is unlikely to contribute significantly to the thorny skate's risk of extinction.

Growth rate/productivity

Individual workshop participants evaluated the available information on thorny skate life history traits as they relate to this factor. As summarized in the **Reproduction, Growth, and Demography** section in the status review, thorny skates have low inherent productivity due to their late age at maturity, low fecundity, slow population growth rates, and long generation times (20 years). This low productivity makes thorny skate populations vulnerable to overexploitation, and slow to recover from depletion. Due to these inherent biological constraints, The mean score we calculated based on the workshop participants' scores corresponds to a *Low to Moderate* ranking rangewide, as this factor is likely to contribute significantly to the thorny skate's risk of extinction.

Spatial structure/connectivity

Individual workshop participants evaluated the available information on thorny skate spatial structure (tagging and genetics information) summarized in the **Population Structure** section of the status review. The thorny skate has a very broad range, including across the entire North Atlantic Ocean. The species is mobile, and some connectivity across the range is apparent from both tagging and genetics data. At the southern edges, there is an indication that a contraction or northward shift may be occurring, however recent data show an increase in abundance in the southern range in US waters. The mean score we calculated based on the workshop participants' scores corresponds to a *Very Low to Low* ranking rangewide, as this factor is very unlikely to contribute significantly to the thorny skate's risk of extinction.

Diversity

Individual workshop participants evaluated the available information on thorny skate diversity summarized in the **Population Structure** section of the status review. The available genetics studies indicate that thorny skate populations have the highest genetic diversity amongst skate species, and there is reproductive connectivity along a continuum rangewide. Therefore, genetic diversity appears to be sufficiently high, and not indicative of isolated or depleted populations. Thorny skates do not appear to be at risk due to substantial changes or loss of variation in life history traits, population demography, morphology, behavior, or genetic characteristics. The mean score we calculated based on the workshop participants' scores corresponds to a *Very Low to Low* ranking rangewide, as this factor is very unlikely to contribute significantly to the thorny skate's risk of extinction.

Threats Assessment

Individual workshop participants identified several threats in the low to moderate category for contribution to extinction risk including: climate change, manmade non-fishing habitat impacts, commercial discards, commercial landings, global and national climate regulation, and inadequacy of existing NAFO regulations (Table 5). Both climate change and global or national climate change regulations received the most likelihood points in the moderate contribution to extinction risk category. Only one threat, climate change received likelihood points in the high contribution category. No threats considered by individual workshop participants were given an overall average score to classify as high or very high contributions to extinction risk of thorny skate. All individual workshop participants' gave point allocation for very low contribution to extinction risk from threats such as recreational fishing, recreational discards, educational collection, and stochastic events.

Table 5. Qualitative ranking of threats for the thorny skate range-wide. Threats were scored using 5 likelihood points distributed in the following bins: 1- very low, 2-low, 3- medium, 4-high, 5-very high. Mean represents the overall workshop participants' average, SD represents the standard deviation based on overall likelihood point allocation given by workshop participants, and range represents the distributions of likelihood points allocated for each threat by workshop participants.

Listing Factor	Threat	Mean	SD	Range
A) The present or threatened destruction, modification, or curtailment of habitat or range	Climate Change	2.3	0.8	1-4
	Other manmade non-fishing habitat impacts (e.g. drilling)	2.0	0.6	1-3
	Bottom Fishing	1.8	0.6	1-3
B) Over-utilization for commercial, recreational, scientific, or educational purposes	Commercial Landings	2.0	0.8	1-3
	Commercial Discards	2.2	0.7	1-3
	IUU Fishing	1.7	0.8	1-3
	Ghost Fishing	1.4	0.7	1-3
	Recreational Landings	1.0	0.0	1
	Recreational Discards	1.0	0.0	1
	Scientific Research	1.2	0.4	1-2
	Educational	1.0	0.0	1
C) Disease or predation	Disease	1.2	0.4	1-2
	Predation	1.5	0.5	1-2
D) Inadequacy of existing regulatory mechanisms	US Fishing Regulations	1.5	0.7	1-3
	Other global or national environmental regulations	1.4	0.5	1-2
	Global or National Climate Change Regulations	2.3	0.7	1-3
	Canadian Fishery Regulations	1.7	0.6	1-3
	NAFO	2.2	0.7	1-3
	Northeast Atlantic (e.g. EU, Noway/ Iceland, NEAFC)	1.9	0.6	1-3
E) Other Natural or man-made factors	Manmade catastrophic events (e.g Oil spills)	1.2	0.4	1-2
	Stochastic Events	1.0	0.0	1

Habitat Destruction, Modification, or Curtailment

Individual workshop participants evaluated the available information on habitat use and distributions of thorny skate summarized in the status review. Overall, the thorny skate is a habitat generalist in the marine environment, and not substantially dependent on any particular habitat type. It occurs in coastal and offshore waters, and is not dependent during any life stage on more vulnerable estuarine habitats. Thorny skate habitat use is influenced by temperature and prey distributions, but they have broad temperature tolerances and an opportunistic diet, making them less vulnerable to habitat destruction. Ocean temperature changes due to climate change may be contributing to a contraction of their range at their southern edges. They also appear to have comparatively low exposure to potentially harmful pollutants, and there is no information suggesting their individual fitness or populations are threatened by pollution. The mean score we calculated based on the workshop participants' scores corresponds to climate change and non-fishing related modifications to habitat presenting a *Low to Moderate* contribution to extinction risk.

Overutilization

Individual workshop participants evaluated the available information on fishing mortality and abundance trends of thorny skate summarized in the status review. Overutilization for commercial purposes was once considered one of the primary threats to thorny skate populations. Significant declines have been documented throughout much of the thorny skate's range due to historic fishing pressure. While the most recent information suggests that several stocks declines have halted due to fishing restrictions. Populations appear to be stable or slowly increasing, with millions of individuals remaining in the Northwest Atlantic alone. Therefore, there appears to be a low likelihood of further population declines. The mean score we calculated based on the workshop participants' scores corresponds to a *Very Low or Low* ranking for all threats in this category, with the commercial landings and commercial discards receiving scores of slightly higher than low contributions to overall extinction risk.

Disease or Predation

Individual workshop participants evaluated the available information on disease and predation summarized in the status review. Overall, there is minimal information available with which to evaluate these threats. In general, thorny skate may be susceptible to diseases, but there is no evidence that disease has ever caused declines in populations. Regarding predation, there is no indication that this species would be threatened by excessive predation pressure. Therefore, the mean score we calculated based on the workshop participants' scores corresponds to a *Very Low* ranking for the species rangewide, as it is very unlikely that these threats contribute or will contribute to the decline of the species.

Inadequacy of Existing Regulatory Mechanisms

Individual workshop participants evaluated the available information on fisheries management regulations and abundance trends of thorny skate summarized in the status review. The inadequacy of regulatory mechanisms to control the harvests of thorny skates was once considered a significant threat to their populations. The best available information indicates that legal protections for thorny skate vary between outright prohibitions on landings in the U.S. and much of the Northeast Atlantic, with limited fishing permitted in Canada and Iceland. While thorny skate are also a bycatch species within many fisheries, stable population numbers indicate existing protections are sufficient through much of its range. The mean score we calculated based on the workshop participants' scores corresponds to both global/national climate change regulations and NAFO fishing regulations presenting *Low to Moderate* contributions to extinction risk. However, panelists also noted uncertainty with expertise related to other global or national environmental regulations in this category.

Other Natural or Manmade Threats

Individual workshop participants evaluated the available information on other potential threats as summarized in the status review. Natural threats focused on the thorny skate's inherent biological vulnerability which is also reflected in the demographic factors described above. The species has low productivity because of its life history characteristics, and is vulnerable to exploitation and population perturbations. Populations can be quickly depleted and take many years to recover. However, their mobility, high genetic diversity, and generalist habitat and diet strategy contribute to a comparatively low risk of extinction. The mean score we calculated based on the workshop participants' scores corresponds to both manmade catastrophic events stochastic events presenting *Very Low* contributions to extinction risk.

Overall Risk Summary

Overall, the mean score we calculated based on the workshop participants' risk scores corresponds to a 93% likelihood of a *Low* risk of extinction, currently or in the foreseeable future (defined by the workshop participants as 40 years). The distributions of likelihood points used in the Overall Extinction Risk Analysis are summarized below (Table 6).

Table 6. Overall level of extinction risk for thorny skate. Likelihood points were distributed amongst each of the categories based upon each workshop participant's expert judgment.

	Current Level of Extinction Risk		
	Low Risk	Moderate Risk	High Risk
Range wide	93.3%	6.6%	0%

None of the workshop participants indicated that there was any likelihood of the thorny skate having a *High* risk of extinction. There was very little likelihood of a *Moderate* risk of extinction. This was due to uncertainty in climate change and national and global climate change

regulation, potential habitat modification (e.g. increased demands on ocean for wind farms, etc.), and concern about the adequacy of current and future regulatory mechanisms, including fisheries rangewide.

To conclude, the thorny skate has been subjected to considerable fishing pressure for many decades, but improved fisheries management efforts in recent years have reduced fishing mortality rates on thorny skate stocks, and populations are no longer declining. Recovery is likely to take decades, however, Barndoor skate populations saw exponential recovery from 1990-2005 (NEFSC 2009), so the recovery timeline may be shorter. Demographic risks are mostly low and significant threats have been reduced. Based upon the available information summarized here, the workshop participant provided their individual expert opinions, which, taken together as a mean score indicates that thorny skate has a low risk of extinction, assuming the dominant threats to their populations continue to be managed.

SIGNIFICANT PORTION OF ITS RANGE ANALYSIS

The definitions of both “threatened” and “endangered” under the ESA contain the term “significant portion of its range” as an area smaller than the entire range of the species which must be considered when evaluating a species risk of extinction. On July 1, 2014, the Services published the Significant Portion of its Range (SPR) Policy, which provides our interpretation and application for how to evaluate whether a species is in danger of extinction, or likely to become so in the foreseeable future, in a “significant portion of its range” (79 FR 37578; July 1, 2014).

Because we found that the thorny skate is at a low risk of extinction throughout its range, under the SPR Policy, we must go on to evaluate whether the species is in danger of extinction, or likely to become so in the foreseeable future, in a “significant portion of its range.” The SPR Policy explains that it is necessary to fully evaluate a particular portion for potential listing under the “significant portion of its range” authority only if substantial information indicates that the members of the species in a particular area are likely both to meet the test for biological significance and to be currently endangered or threatened in that area.

Making this preliminary determination triggers a need for further review, but does not prejudice whether the portion actually meets these standards such that the species should be listed. To identify only those portions that warrant further consideration, we will determine whether there is substantial information indicating that (1) the portions may be significant and (2) the species may be in danger of extinction in those portions or likely to become so within the foreseeable future. We emphasize that answering these questions in the affirmative is not a determination that the species is endangered or threatened throughout a significant portion of its range—rather, it is a step in determining whether a more detailed analysis of the issue is required (79 FR 37578, at 37586; July 1, 2014).

Thus, the preliminary determination that a portion may be both significant and endangered or threatened merely requires us to engage in a more detailed analysis to determine whether the

standards are actually met (79 FR 37578, at 37587). Unless both standards are met, listing is not warranted. The SPR policy further explains that, depending on the particular facts of each situation, we may find it is more efficient to address the significance issue first, but in other cases it will make more sense to examine the status of the species in the potentially significant portions first. Whichever question is asked first, an affirmative answer is required to proceed to the second question. *Id.* “[I]f we determine that a portion of the range is not ‘significant,’ we will not need to determine whether the species is endangered or threatened there; if we determine that the species is not endangered or threatened in a portion of its range, we will not need to determine if that portion is ‘significant.’” *Id.* Thus, if the answer to the first question is negative—whether that regards the significance question or the status question—then the analysis concludes and listing is not warranted.

As defined in the SPR Policy, a portion of a species’ range is “significant” “if the species is not currently endangered or threatened throughout its range, but the portion’s contribution to the viability of the species is so important that, without the members in that portion, the species would be in danger of extinction, or likely to become so in the foreseeable future, throughout all of its range” (79 FR 37578, at 37609). For purposes of the SPR Policy, “[t]he range of a species is considered to be the general geographical area within which that species can be found at the time FWS or NMFS makes any particular status determination. This range includes those areas used throughout all or part of the species’ life cycle, even if they are not used regularly (e.g., seasonal habitats). Lost historical range is relevant to the analysis of the status of the species, but it cannot constitute a significant portion of a species’ range”

Applying the SPR policy to the thorny skate, we first evaluated whether there is substantial information indicating that any portions of the species’ range may be significant. After a review of the best available information, we find that the data do not indicate any portion of the thorny skate’s range as being more significant than another when using the SPR policy. Thorny skates are distributed across the North Atlantic and have very few restrictions governing their movements. The Northwest Atlantic region was identified by petitioners as a portion of the species’ range in which it is likely at risk of extinction. On a conference call in June 2016, workshop participants provided their expert opinions on questions related to abundance, productivity, spatial distribution, and diversity outlined in the NMFS listing guidance policy specific to significance of portions. The workshop participants answered the following questions on significance of portions for both the Northeast Atlantic and Northwest Atlantic.

Abundance:

- Without that portion, would the level of abundance of the remainder of the species cause the species to be at moderate or high risk of extinction due to environmental variation or anthropogenic perturbations (of the patterns and magnitudes observed in the past and expected in the future)?
- Without that portion, would the abundance of the remainder of the species be so low, or variability in abundance so high, that it would be at moderate or high risk of extinction due to compensatory processes?

- Without that portion, would abundance of the remainder of the species be so low that its genetic diversity would be at risk due to inbreeding depression, loss of genetic variation, or fixation of deleterious alleles?
- Without that portion, would abundance of the remainder of the species be so low that it would be at moderate or high risk of extinction due to its inability to provide important ecological functions throughout its life-cycle?
- Without that portion, would the abundance of the remainder of the species be so low that it would be at risk due to demographic stochasticity?

Productivity:

- Without that portion, would the average population growth rate of the remainder of the species be below replacement such that it would be at moderate or high risk of satisfying the abundance conditions described above?
- Without that portion, would the average population growth rate of the remainder of the species be below replacement such that it is unable to exploit requisite habitats/niches/etc. or at risk due to compensatory processes during any life-history stage?
- Without that portion, would the remainder of the species exhibit trends or shifts in demographic or reproductive traits that portend declines in the per capita growth rate, which pose a risk of satisfying any of the preceding conditions?

Spatial distribution:

- Will the loss of one or more of the portions significantly increase the risk of extinction to the species as a whole by making the species more vulnerable to catastrophic events such as storms, disease or temperature anomalies?
- Will connectivity between portions of the species' range be maintained if a portion is lost (e.g., does the loss of one portion of the range of the species create isolated groups or populations?)?
- Are there particular habitat types that the species occupies that are only found in certain portions of the species' range? If so, would these habitat types be accessible if a portion or portions of the range of the species are lost?
- Are threats to the species concentrated in particular portions of the species' range and if so, do these threats pose an increased risk of extinction to those portions' persistence?

Diversity:

- Will unique genetic diversity be lost if a portion of the range of the species is lost?
- Does the loss of this genetic diversity pose an increased risk of extinction to the species?

Individual workshop participants answered no to all of the abundance, productivity and diversity questions. One workshop participant answered “yes” to two spatial distribution questions. This workshop participant stated that loss of either the Northwest or Northeast Atlantic portion would result in loss of connectivity between portions of the species' range and would create isolated groups or populations. This same participant also stated that there are threats to the species

concentrated in particular portions of the species' range and therefore if either the Northwest or Northeast portions were lost, these threats would pose an increased risk of extinction to those portions' persistence. All other workshop participants answered "no" to all of the spatial distribution questions.

We considered the individual input of workshop participants and determined that there is not substantial information indicating that any portions of the species range may be significant. Given estimates of 1.8 billion animals in Northwest Atlantic waters, which represent 30-40% of the overall population (COSEWIC, 2012), loss of the Northwest Atlantic population would have a large impact on the species rangewide, but would not put the species at a moderate or high risk of extinction. Additionally, using the best available genetic research, thorny skates have the highest diversity relative to other skates and the highest diversity occurs at the central portion of their range. When considering productivity, workshop participants noted, and we agree, that because of high abundance, the average growth rate for the species does not depend on the growth rate in the Northwest Atlantic and vice versa for the Northeast Atlantic. Regarding shifts in demographic or reproductive traits, none of the workshop participants could identify evidence that a decline in the Northwest Atlantic would portend a decline in the Northeast Atlantic. Given the large spatial distribution of thorny skate and the foreseeable future of 40 years, none of the workshop participants could identify a stochastic event that could impact the entire Northwest Atlantic or Northeast Atlantic distributions of thorny skate. There is no information to suggest that loss of any portion would severely fragment and isolate the species to the point where individuals would be precluded from moving to suitable habitats or have an increased vulnerability to threats. The loss of either the Northwest Atlantic population or the Northeast Atlantic population would result in the loss of connectivity rangewide, given that it is a continuous population. However, loss of the Northwest Atlantic population would not affect spatial connectivity of the Northeast Atlantic population and vice versa. Some genetic differentiation is present between the Northwest Atlantic and Northeast Atlantic, but the central portion of the range appears to bridge diversity between these two areas. This is likely made possible by the continuous distribution and depth range of the species. There is no substantial evidence to indicate that the loss of genetic diversity from one portion of the species' range would result in the remaining populations lacking enough genetic diversity to allow for adaptations to changing environmental conditions.

Given the above answers to abundance, productivity, spatial distribution, and diversity questions and our analysis there is no indication that individual loss of either the Northeast Atlantic or Northwest Atlantic part of the species' range would constitute a moderate or high extinction risk to the global species.

The U.S. population was also identified as a region of the species range worthy of listing by the petitioners. However due to our analysis and consideration of individual workshop participant's expert opinions for the larger Northwestern and Northeastern Atlantic region and findings that neither of these constitute a significant portion of its range, and given the U.S. represents only a small portion of the global range of the thorny skates, there is little evidence to support the significance prong. Furthermore, there is no indication that loss of the U.S. part of the species' range would constitute a moderate or high extinction risk to the global species. As was mentioned previously, the available population and trend data do not indicate that past declines

in the US have affected global populations of thorny skate. Thus, the U.S. would not qualify as “significant” under the SPR Policy. Likewise, there is no substantial evidence to indicate that the loss of genetic diversity from one portion of the species’ range would result in the remaining populations lacking enough genetic diversity to allow for adaptations to changing environmental conditions. Similarly, there is no information to suggest that loss of any portion would severely fragment and isolate the species to the point where individuals would be precluded from moving to suitable habitats or have an increased vulnerability to threats. In other words, loss of any portion of its range would not likely isolate the species to the point where the remaining populations would be at risk of extinction from demographic processes.

In summary, areas exhibiting source-sink dynamics, which could affect the survival of the species, were not evident in any part of the thorny skates’ range. There is also no evidence of a portion that encompasses aspects that are important to specific life history events, but another portion that does not, where loss of the former portion would severely impact the growth, reproduction, or survival of the entire species. In other words, the viability of the species does not appear to depend on the productivity of the population or the environmental characteristics in any one portion. It is important to note that the overall distribution of the thorny skate is still uncertain. As better data become available, the species distribution (and potentially significant portions of its range) will become better resolved; however, at this time, there is no evidence to suggest that any specific portion of the species’ range has increased importance over another with respect to the species’ survival. Thus, under the SPR, NMFS preliminarily determines that a portion of the species’ range may be both significant and endangered or threatened has not been met.

Based upon our review of the best available information, we determined that there is no portion of the range that has increased importance over any other with respect to species survival and therefore, there are no portions of the range that qualify as significant under the SPR policy.

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